NONRESIDENTIAL MARKET SHARE TRACKING STUDY

FINAL REPORT ON PHASES 1 AND 2

CONSULTANT REPORT

Prepared For:
California Energy Commission

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With
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An Employee-Owned Company

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1. Executive Summary

1.1 Introduction

1.1.1 Background

In the late 1990s, a group of California energy agencies and utilities decided to document baseline conditions of market indicators. By documenting conditions, the group aimed to help:

- Program planners determine what technologies should be promoted, as opposed to which markets were already mature.
- Program evaluators document market change.

As part of this effort, the group called for a scoping study in 1998-99. *The Efficiency Market Share Needs Assessment and Feasibility Scoping Study* identified technologies that required further study, as well as methods that would help the group achieve its objectives.[1]

Following the scoping study, the California Energy Commission (CEC) selected Aspen Systems Corporation to perform the Nonresidential Market Share Tracking Study in 2000. The work was funded by the California Public Goods Charge Energy Efficiency and Demand Side Management Funds collected by the state's investor-owned utilities, as authorized by the California Public Utilities Commission. Following is the final report from the tracking study.

1.1.2 Purpose

The purpose of the tracking study was to collect data on market shares, quantities, and prices of energy-efficient vs. standard-efficiency technologies. The study also identified market-characterization attributes, market pathways, and decision factors for selected technologies used in industrial and, to a lesser extent, commercial facilities. Data was obtained for the following:

- Packaged air conditioning
- Lighting
- Windows
- Energy management systems
- Chillers
- Motors
- Compressed-air systems and optimization
- Blowers
- Automatic lubrication systems
- Water recovery and reuse
- Electronic process controls
- Maintenance
- Fluid process pumping
- Gas process heating

1.1.3 Project Data Sources

Aspen collected data through:

- Secondary data source search
- Primary data collection involving 560 on-site surveys at manufacturing facilities
- Primary data collection involving telephone interviews with 104 upstream market actors (manufacturers, distributors, dealers, installers, and designers)

1.1.3.1 Secondary Data Collection

The secondary data collection focused on lighting, chillers, and windows. Aspen evaluated data from 38 secondary sources, including California Measurement Advisory Council (CALMAC) reports, California Board for Energy Efficiency (CBEE) studies, trade journals, federal databases and reports, commercial studies, and the Internet, for relevance to the tracking study. Specific sources from which Aspen obtained data included the:

- *Database for Energy Efficiency Resources (DEER) Update Study*[2]
- *Non-Residential New Construction (NRNC) Baseline Study*[3]
- *California Residential Efficiency Market Share Tracking Study*[4]
- *California Institute of Food and Agricultural Research Survey on Energy Management in the Food Industry*[5]
- *C&I New Construction and Retrofit Lighting Design and Practices*[6]

1.1.3.2 Primary Data Collection

The primary data collection via on-site surveys at manufacturing plants was conducted in two phases. Phase 1, conducted in 2001–2002, dealt with plants in Standard Industrial Classification (SIC) 20, 35, and 36. Phase 2, conducted in late 2002 through mid-2003, covered the remaining 17 manufacturing-sector SIC categories (21-34 and 37-39). The primary data collection via telephone interviews was performed in 2003, with market actor samples drawn from commercially purchased business lists.

In all three cases, the collected data were cleaned, weighted, and analyzed to obtain the estimates of interest. Estimates are provided in tables and the delivered datasets. When less than 10 observations were available for an estimate, the estimate was withheld either due to concerns regarding confidentiality of respondents or reliability of the estimate due to large sampling error. In such cases, the tables and database contain the letter "W" in place of an estimate value.

The findings of the tracking study are presented in this final report and accompanying data sets. Volume I of the final report contains an Executive Summary (Chapter 1) followed by four chapters. Chapter 2 provides an introduction that discusses the project goals and approach and the report organization. Chapter 3 provides selected analysis results for each of the major technologies studied. Chapter 4 provides data collection and analysis methodology. Chapter 5 is a users' guide for the Public Database. Chapter 6 describes the two databases—Confidential Database and Public Database—Aspen developed for the tracking study.

Data from the secondary data collection, the primary data collection, and the statistical analysis of collected data were used to create two datasets. The Public Access Dataset (the Public Database) contains summary statistics for the technologies in segments of interest. While a Confidential Dataset (the Confidential Database) contains the raw, masked original survey data. Both datasets were delivered to CEC. Volume II of the report contains 11 appendices, including:

- Appendix A. Phase 1 Industrial Purchases and Practices Survey
- Appendix B. Phase 2 Industrial Purchases and Practices Survey
- Appendix C. Upstream Market Actor Telephone Survey Questionnaires
- Appendix D. Data Dictionary for the Public Database
- Appendix E. Industrial Supplier/Expert Pre-Survey Interview Results
- Appendix F. Secondary Sources Bibliography
- Appendix G. Phase 1 Phone Recruiting Survey Instrument
- Appendix H. Phase 2 Phone Recruiting Survey Instrument
- Appendix I. Phase 1 List of Quality Control Checks
- Appendix J. Phase 2 List of Quality Control Checks
- Appendix K. Public Database User Manual

1.2 Principal Results

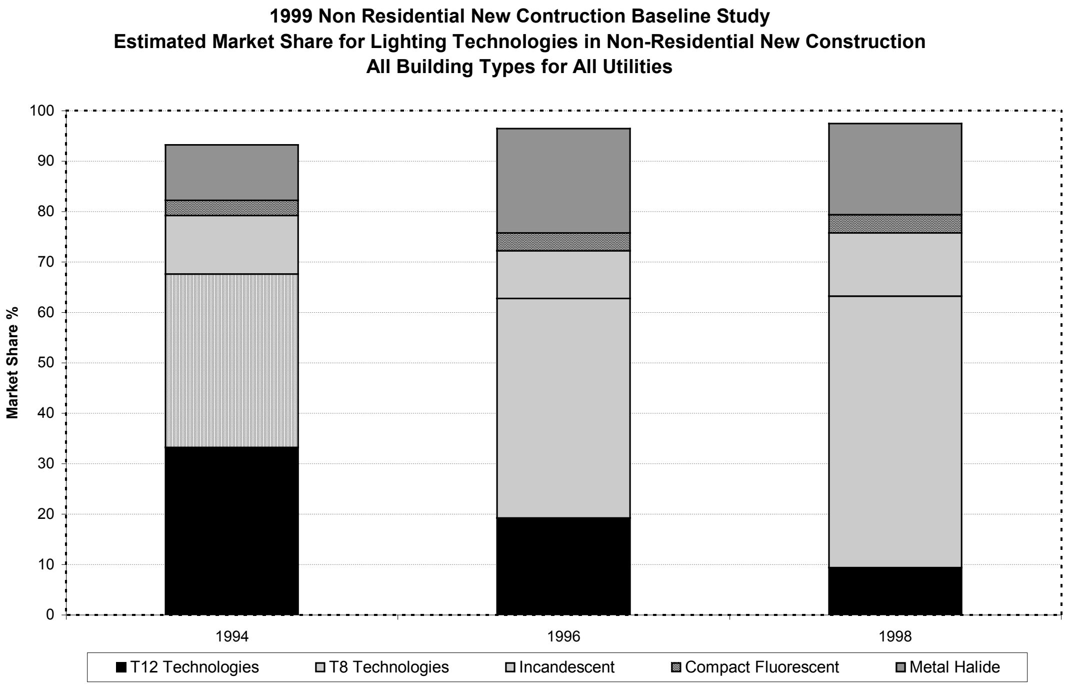
1.2.1 Commercial and Industrial Sectors

1.2.1.1 Lighting

Secondary Data: Non-Residential New Construction Baseline Study Review

Aspen analyzed the NRNC database and computed more than 4,000 lighting market-share estimates. The NRNC database contains technology-specific counts collected through on-site surveys from 1994 to 1998. Exhibit 1-1 shows selected lighting market-share estimates computed from these data. A more detailed table containing these market-share estimates and their standard errors is found in Chapter 3 as Exhibit 3-1.

Exhibit 1-1. Selected Secondary Lighting Market Shares from Public Database



Analysis of the NRNC indicated that the market shares of efficient lighting technologies are growing:

- In 1998, compact fluorescent lights (CFLs) had about 3.5 percent of the California market. An estimate provided by a representative of a large lighting manufacturer places the national average 2.5 percent.
- The CFL market share in California increased from 3 percent in 1994 to 3.5 percent in 1998. Error bars (not shown) on these estimates indicate that this growth might be spurious. Additional data from 2000 or 2001 is needed to clarify this question.
- The share of T12 lamp systems indicates a consistent downward trend, from 33 percent share in 1994, to 19 percent in 1996, to 9 percent in 1998.
- The acknowledged efficiency choice of T8 lamp and electronic-ballast combination grew steadily from 31 percent in 1994, to 41 percent in 1996, to about 52 percent in 1998.

Primary Data: Upstream Market Actor Surveys

Most lighting manufacturers declined to discuss the market quantitatively. However, a representative from a very large manufacturing firm, who most likely has access to reliable internal market research information, shared the following data:

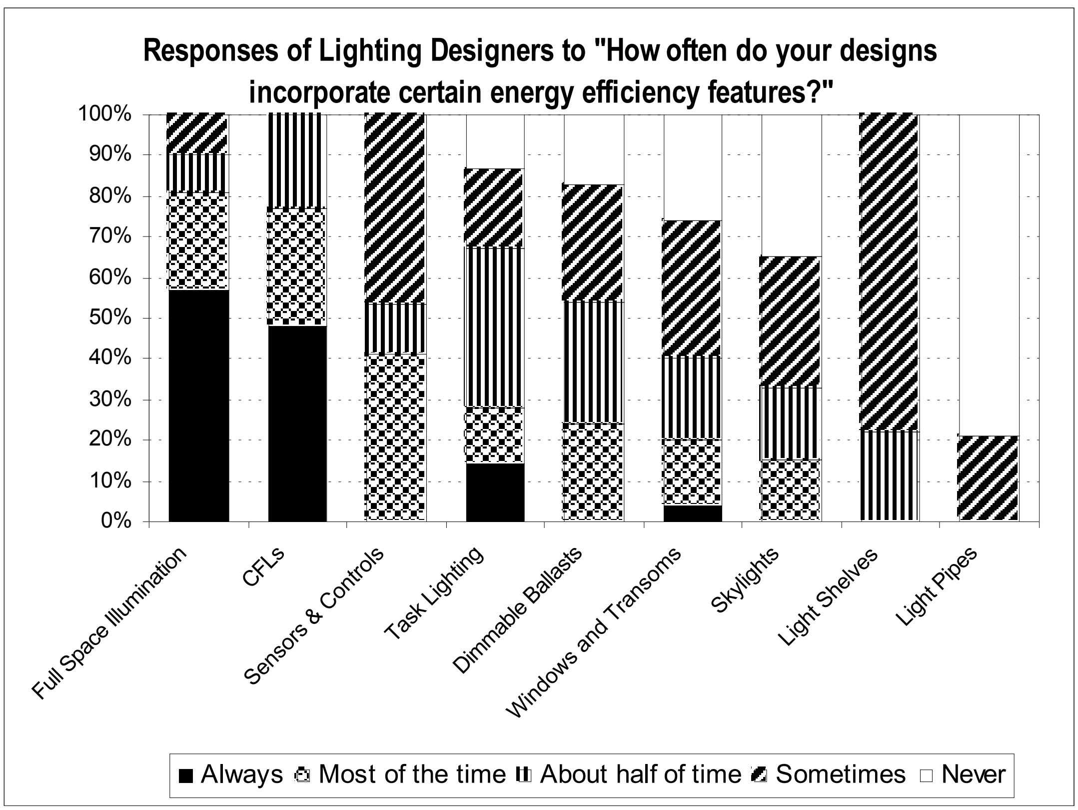
- T8 share in California was about 55 percent in 2002, which is consistent with the NRNC-based share estimate of 52 percent in 1998 in all commercial building types statewide.

- The U.S. share of CFLs was 2.5 percent in 2002, and CFL sales in California were about 10 million to 15 million lamps in 2002.

Based on lighting manufacturers' statements and additional data, the California market share for CFLs in 2002 would be about 3.8 percent, or 150 percent of the U.S. average. This estimate is consistent with the data in the NRNC study of about 3.5 percent in 1998.

Lighting designers were interviewed to obtain data concerning how frequently projects featured energy-efficient technologies. Interviewed designers were from a statistical sample, ranging from small lighting-design consultants to large architect-engineers to electrical contractors. The sample was representative of all lighting design activity in the state. Exhibit 1-2 shows their responses. Tabulated data and standard errors are provided in Chapter 3 as Exhibit 3-11.

Exhibit 1-2. Lighting Designers Responses on Incidence of Selected Efficiency Features in Their Designs



Nearly 77 percent of designers stated they used CFLs in their designs "always" or "most of the time." This indicates a high level of market transformation in the upstream design community for CFLs. Task lighting and dimmable ballasts were reported as used "always" or "most of the time" by about 25 percent of the designers surveyed, indicating an established presence in the market. Other efficiency design features, such as the more architecturally based features, were uncommon in the "always" and "most of the time" response categories. The incidence of these responses combined was 20 percent for daylighting with windows and transoms, 0 percent for light shelves, 15 percent for skylights, and 0 percent for light pipes. The proportion reporting “never used" was highest for daylighting with light pipes, with 79 percent reporting “never used.” These findings seem to clearly indicate the value of additional training and education for professionals on the value of the architectural elements, especially light pipes.

Primary Data: Industry Energy End-User Survey

During Phase 2 (2002–2003), Aspen visited manufacturing facilities and obtained estimates of the saturations of T12 and T8 lamps. The saturation of T8 lighting was found to be about 12 percent on a square-footage basis. This percentage is much less than the 52 percent (installed wattage basis) estimated from the NRNC data for “All Commercial Buildings” in 1998 (Exhibit 1-1) and the 55 percent in 2002 estimated by a lighting manufacturers’ representative. It is evident that the transformation to T8 has progressed substantially in commercial buildings, but that there remains much room for additional deployment of T8 systems in industrial facilities.

1.2.1.2 Chillers

Secondary Data: Non-Residential New Construction Baseline Study Review

Aspen analyzed the NRNC to obtain data on the market share for chiller technologies. Based on this analysis, Aspen established high- (less than 1.05), medium- (1.05 through 1.10), and low-efficiency (greater than 1.10) kW/ton ranges. For air-cooled chillers, the performance standard in California was set at 1.13 kW/ton in 1999, and is constant over all capacity ranges.

Exhibit 1-3 illustrates the market share of air- and water-cooled chillers and the distribution of chiller tonnage installed in California across these efficiency classes from 1994 through 1998.

For air-cooled units that were less than 150 tons (n=40), nearly 96 percent of the tonnage installed fell into the “low efficiency” class (1.10 kW/ton or more). Results for air-cooled units that were 150 through 299 tons (n=8) were inconclusive, as only 8 chillers were reported. It is important to note that air-cooled units are less likely to be used for larger capacity applications, explaining the small sample size.

For water-cooled chillers, installed units that were less than 150 tons size (n=25) had 40 percent of tonnage in the medium- and high-efficiency classes. Units installed that were 150 through 299 tons had about 41 percent of the tonnage in the medium- and high-efficiency classes. Units greater than or equal to 300 tons had 51 percent of the tonnage sold from the medium- and high-efficiency classes.

Exhibit 1-3. Key Chiller Results

1999 Non-Residential New Construction Baseline Study
Market Share for Chiller Technologies (1994 - 1998)

Chiller Type	Chiller Capacity	Efficiency Class	Efficiency Range kW/Ton	Market Share	Sample Size	Standard Error
Air Cooled						
	Less than 150 tons	High	Less than 1.05	2.4%	3	1.9%
	Less than 150 tons	Medium	1.05 through 1.10	1.7%	3	1.1%
	Less than 150 tons	Low	Greater than 1.10	95.8%	34	2.3%
			Total:	**99.9%**	**40**	
	150 through 299 tons	High	Less than 1.05	50.0%	2	23.0%
	150 through 299 tons	Medium	1.05 through 1.10	4.3%	1	4.8%
	150 through 299 tons	Low	Greater than 1.10	45.7%	5	22.3%
			Total:	**100.0%**	**8**	
Water Cooled						
	Less than 150 tons	High	Less than 0.75	15.2%	4	8.2%
	Less than 150 tons	Medium	0.75 through 0.85	25.0%	4	16.4%
	Less than 150 tons	Low	Greater than 0.85	59.8%	17	16.0%
			Total:	**100.0%**	**25**	
	150 through 299 Tons	High	Less than 0.59	14.8%	7	9.0%
	150 through 299 Tons	Medium	0.59 through 0.75	26.5%	11	13.4%
	150 through 299 Tons	Low	Greater than 0.75	58.7%	10	16.4%
			Total:	**100.0%**	**28**	
	Greater than or equal 300 tons	High	Less than 0.56	7.6%	12	3.0%
	Greater than or equal 300 tons	Medium	0.56 through 0.65	44.3%	23	12.0%
	Greater than or equal 300 tons	Low	Greater than 0.65	48.1%	20	12.2%
			Total:	**100.0%**	**55**	

Aspen analysis of data from Non-Residential New Construction Baseline Study by RLW Analytics, Inc. for SCE, 1999

Primary Data: Upstream Market Actor Surveys

Aspen conducted market actor telephone interviews with representatives from the four largest electric chiller manufacturers in the United States. These manufacturers represent the majority of chiller tonnage installed in the United States. Interviews were also conducted with a statistical sample of 23 chiller contractors located throughout California. The following data were obtained:

- Contractors reported 70 percent of sales for space cooling; 29 percent for process cooling
- Manufacturers reported 74 percent of sales for space cooling; 26 percent for process cooling
- Contractors reported 23 percent of sales for new construction; 68 percent for renovation, retrofit, or expansion of existing facilities
- Manufacturers reported 43 percent of sales for new construction; 58 percent for renovation, retrofit, or expansion of existing facilities

Manufacturers and contractors both emphasized the retrofit, which is expected as the life of chillers is typically 15 to 20 years, with many running longer.
Exhibit 1-4 provides information on the delivery times of chillers based on information obtained from the market actor interviews. A common barrier to purchasing efficient chillers is potential delivery delays. The manufacturers and contractors surveyed stated that larger units have longer delivery cycles than smaller units, however, neither group reported significant delivery delays for units that feature efficiency options.

Exhibit 1-4. Chiller Delivery Schedules

Chiller Description	Average Delivery Time (Weeks) Reported by:	
	Manufacturers [n = 3]	Contractors [n = 20]
"Standard" Chillers, 200 to 500 tons	9.3	6.5
Standard Error	(0.9)	(1.4)
"Standard" Chillers, 500 tons and Larger	9.8	11.7
Standard Error	(1.3)	(0.4)
Additional time w/ Energy-Efficient Options	0.4	0.1
Standard Error	(0.4)	(0.1)

1.2.1.3 Windows

Secondary Data: Non-Residential New Construction Baseline Study Review

Aspen analyzed NRNC data to obtain the market share for various window technologies from 1994 through 1998 (Exhibit 1-5). In summary, single-pane windows dominated the market with a 78 percent share in 1994, 72 percent in 1996, and 79 percent in 1998. The market share of more efficient two-pane windows did not grow significantly in the new construction market, with the sum of the market shares of the three versions being about 18 percent in 1994, 27 percent in 1996, and 21 percent in 1998.

Exhibit 1-5. Market-Share Estimates for Windows

1999 Non-Residential New Construction Baseline Study
Estimated Market Share for Windows Technologies
In Non-Residential New Construction

Utility Selected: **PG&E/SCE/SDG&E**

Building Types Selected: **All**

Technology		1994	1996	1998
Single Pane				
Clear Glass		30.40%	27.06%	5.11%
	Standard Error:	(7.5%)	(4.6%)	(1.2%)
Reflective Glass		4.13%	4.21%	31.04%
	Standard Error:	(2.1%)	(1.3%)	(7.6%)
Tinted Glass		43.75%	41.34%	43.14%
	Standard Error:	(8.0%)	(5.9%)	(7.6%)
Double Pane				
Clear Glass		2.29%	6.26%	3.32%
	Standard Error:	(0.6%)	(1.6%)	(1.3%)
Reflective Glass		0.15%	2.52%	0.04%
	Standard Error:	(0.2%)	(1.3%)	(0.04%)
Tinted Glass		15.65%	18.15%	17.32%
	Standard Error:	(3.6%)	(3.2%)	(5.0%)
Triple Pane				
Clear Glass		3.63%	0.00%	0.02%
	Standard Error:	(1.7%)	(0.00%)	(0.01%)

Note: Estimates created by Aspen analysis of data from the 1999 Non-Residential New Construction Baseline Study, RLW Analytics, Inc. prepared for SCE, 1999.

Primary Data: Upstream Market Actor Surveys

According to NRNC data, double-pane windows obtained an 18 percent to 26 percent market share through the 1990s. With the 2001 revision to California's energy efficiency construction code Title 24, which mandates U-factors (window heat-transmission values) in the 0.5 Btu/hr-ft^2-F range for the majority of applications, double-pane windows have nearly become a requirement in new construction. Interviews with market actors in 2003 revealed that the share of double-pane windows had reached 71 percent, and the share of triple-pane windows was about

1.3 percent. These data indicate that the market share of single-pane windows has dropped from an estimated 79 percent in 1998 to about 28 percent.

Even though Title 24 effectively mandates double-pane windows, the market share of double- and triple-pane windows is only 72 percent. Data from the upstream market actor interviews offer an explanation at to why that percentage is not closer to 100 percent.

Window suppliers reported that approximately 65 percent of sales are for the new construction market. The remaining 35 percent is for the renovation/retrofit market. In all likelihood, most of the window sales to the new construction market are double or triple pane. For the replacement/retrofit market, some large replacement projects probably fall under Title 24 requirements, but the majority of replacement sales are in-kind replacement of single-pane windows. If 80 percent of the replacement/retrofit market was in-kind replacement of existing single-pane windows, the result would be the 28 percent estimate of single-pane windows in 2002.

Efficiency features in windows have a cost, and market actors reported the price increases for several popular efficiency features (Exhibit 1-6). The average price premium reported for double-pane windows was 32 percent, which may explain why regulation was required to significantly increase the market share of double-pane windows. Secondary data confirmed the estimated 32 percent price premium for double-pane windows.

Exhibit 1-6. Mean of Percentage Price Premiums Quoted by Window Suppliers for Various Energy-Efficiency Features Added to a "No Frills" 4'x5' Single-Pane Window with a Mean Price of $384 [n = 24]

Energy-Efficiency Feature	Price Premium	Std. Error
Double Pane	31.5%	6.4%
Triple Pane*	6.8%	4.9%
Low-Emissivity Coating	9.4%	3.1%
Tinting	8.2%	3.8%
Reflective Coating	7.6%	4.1%
Other (e.g., laminated)	1.1%	1.1%

* Price understood to be relative to a double-pane window.

1.2.2 Industrial Sector Only

1.2.2.1 Electric Motors

One of the primary objectives of Aspen's Industry Energy End-User Survey was to determine the market share of National Electrical Manufacturers Association (NEMA) premium-efficiency motors for purchases made in the last three years. The survey collected nameplate data on a stratified random sample of more than 2,200 motors sized 1 horsepower and above. Aspen sampled up to 10 motors at each site and over-sampled large motors.

As can be seen in Exhibit 1-7, the overall premium-efficiency market share is estimated at 19 percent in the 2001–2002 industries and about 13 percent in the 2002-2003 SIC categories. For most industry groups, the estimated share of horsepower in NEMA premium-efficiency motors is greater in the large motor size classes than in the smaller one, with SIC 35 as the exception.

Exhibit 1-7. Premium-Efficiency Motor Market Share

Questions and Responses	2001–2002								2002–2003	
	SIC 20		SIC 35		SIC 36		SICs 20, 35, 36		SICs 21-34, 37-39	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
Percentage of hp of motors bought in last 3 years meeting or exceeding NEMA premium-efficiency standards										
1 - 49 hp	22.8%	10.9%	35.7%	7.9%	6.6%	2.2%	**15.8%**	4.1%	**8.5%**	2.7%
50 - 200 hp	18.7%	6.1%	W	W	19.0%	5.0%	**17.5%**	3.4%	**20.2%**	5.6%
Total 1 - 200 hp	21.3%	7.1%	23.4%	9.1%	10.4%	2.5%	**19.0%**	4.2%	**12.6%**	3.1%

W = Withheld

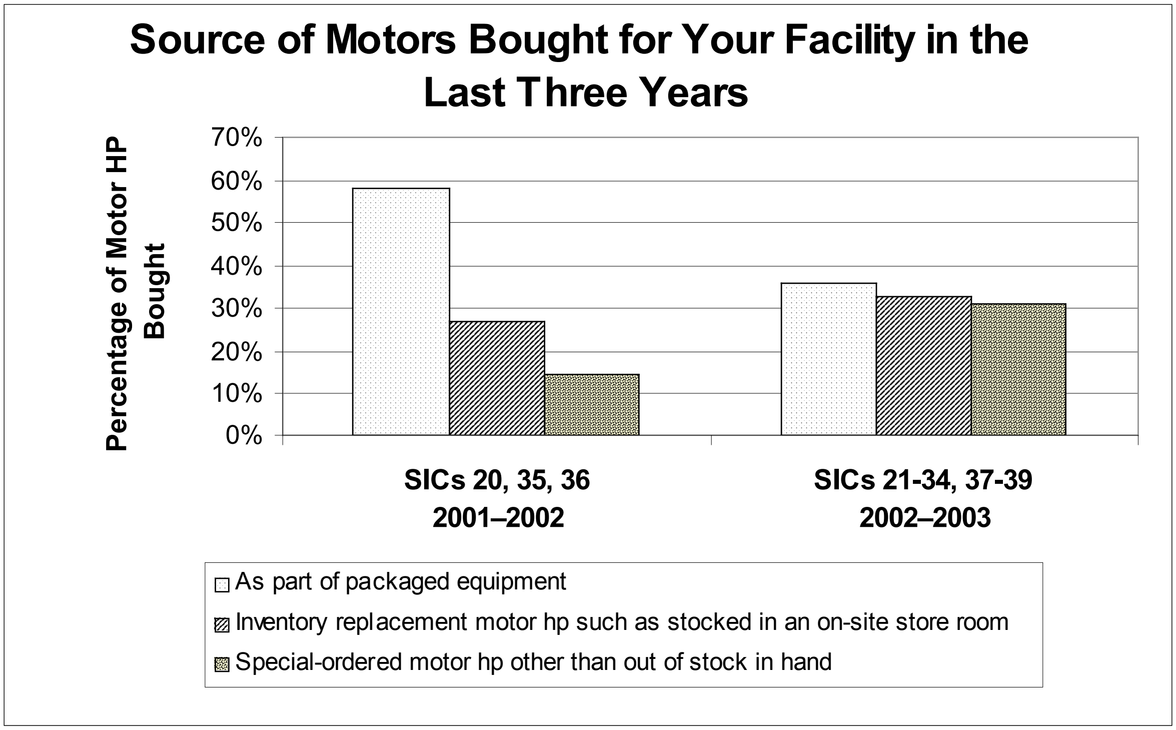
The findings regarding market share of NEMA premium-efficiency motors are key because the Office of Energy Efficiency and Renewable Energy of the U.S. Department of Energy, under its Motor Challenge Program, conducted a national survey of 265 facilities in January through October 1997 that showed that the market penetration of NEMA premium-efficiency motors was about 9 percent in 1997 (*United States Industrial Electric Motor Systems Market Opportunities Assessment*, by Xenergy). California manufacturers appear to be buying premium-efficiency motors at a somewhat higher rate than the national incidence, but considerable opportunities for program action and market transformation still exist. Exhibit 1-8 explains how motors are procured, and may explain why the market share of premium-efficiency motors is still low. More detailed information can be found in Chapter 3 as Exhibit 3-32.

Motors enter plants as:

- Stock motors for replacement inventory
- Custom purchases for specific, often engineered applications
- Components of large machinery items

The tracking study quantified the horsepower entering plants through each channel. In both industry groupings, the largest portion of horsepower enters plants as a component of purchased equipment. For the SIC 20, 35, and 36 group, 58 percent of new motive power entering plants in the past three years were part of packaged machinery or equipment. The efficiency level of these motors is likely unaffected by motor programs or motor standards. In this industry group, 27 percent of the horsepower entered as inventory motors that are stored for stand-ready replacement stock. About 14 percent entered for use in custom applications.

Exhibit 1-8. Shares of New Motor Horsepower Entering Plants via Three Purchase Paths



For the broader industry group, a similar though less-pronounced, trend existed. In the broader group, 36 percent of the horsepower came in as on-board motors in packaged equipment; 33 percent was for inventory; and about 31 percent was for custom applications. The trend suggests that a key thrust for motors efficiency programs will be to work with manufacturers to persuade them to feature premium-efficiency motors in equipment for sale and to work with buyers to drive the demand for these products. Exhibit 1-9 highlights other key findings on motors, including purchasing policy, knowledge of industry terms, and motor rewinding.

Purchasing policy is perhaps as important as motor programs to move efficient motors into the market. The survey sought to capture information relating to this issue. The following results were obtained on purchasing policies, and indicate that an opportunity for education on purchasing policy exists:

- When buying packaged equipment, only 7 percent to 24 percent of firms have a policy to specify NEMA premium-efficiency motors as a feature.
- When buying inventory motors, about 50 percent of Phase 1 firms and 75 percent of Phase 2 firms said they “buy regular” or “have no particular policy on energy efficiency.”

Exhibit 1-9. Selected Other Findings on Motors

Questions and Responses	SIC 20, 35, 36		SIC 21-34, 37-39	
	Estimate	Std. Error	Estimate	Std. Error
Plant has a standard clause or policy to purchase NEMA-premium-efficiency motors when ordering packaged equipment	24.2%	5.9%	6.6%	3.0%
When buying replacement motors, such as those stocked in an on-site store room, do you have a policy about the efficiency level to buy?				
• Premium-efficiency (Phase 1 only)	28.8%	6.8%	NA	NA
• NEMA premium-efficiency (Phase 2 only)	NA	NA	1.1%	0.4%
• “Efficient” (but not necessarily NEMA premium-efficiency (Phare 2 only)	NA	NA	4.5%	2.5%
• Buy regular	5.4%	2.1%	3.1%	1.6%
• Consider tradeoffs between efficiency and price	NA	NA	2.3%	2.1%
• No particular policy on energy efficiency	44.8%	7.1%	71.7%	5.5%
Respondendent understands that the term “premium” efficiency motors means NEMA premium-efficiency	NA	NA	16.3%	4.2%
When asked why rewind motors, proportion who cited the following reasons (of available choices):				
• Lower first cost	55.2%	11.9%	69.0%	8.7%
• Faster turnaround time	39.2%	10.4%	44.3%	9.5%
• To keep older motors that are built better	29.2%	11.9%	2.9%	1.0%
When having a motor rewound, do you require any of the following quality assurance features:				
• Oven chart recorder burnout temperature	2.0%	1.1%	3.3%	2.2%
• Repair report	22.4%	9.6%	26.7%	7.4%
• Winding resistance test results	13.2%	9.1%	15.0%	6.5%
• Core-loss test results	5.5%	3.1%	6.7%	25.4%

The survey also discovered that misunderstanding of NEMA “premium-efficiency” is common, with less than one-sixth of Phase 2 respondents describing the meaning of the term accurately.

In regard to motor rewinding, most respondents that had rewound motors indicated that cost and turnaround times were the driving factors. When asked about how quality control was monitored in the rewinding operations, the respondents cited that they received a repair report in 22 percent to 27 percent of the cases. Only small proportions of customers (1 percent to 13 percent in 2001–2002; 1 percent to 15 percent in 2002–2003) requested more technical diagnostics, such as oven chart recorder burnout temperature and core-loss test results.

1.2.2.2 Process Fluid Pumping Systems

Aspen collected data on process fluid pumping systems only at facilities with pumps totaling at least 50 horsepower. Exhibit 1-10 shows the incidence of firms having taken specific measures in the past three years. The most common action taken was replacing worn impellers or bearings. While this measure does save energy, it is largely a maintenance issue that is likely performed as components wear. The attendant energy benefits may not even be recognized. Activities that directly save energy, such as trimming impellers, replacing with higher efficiency pumps, and increasing pipe diameters, have lower but substantial activity levels. Many of these types of upgrades improve system performance as well as save energy. This segment of the industrial market may be most responsive to programs and messages that stress the non-energy benefits of efficiency measures.

Exhibit 1-10. Pump Efficiency Upgrades Reported in the 2002–2003 Survey

Questions and Responses	SICs 21-34, 37-39	
	Upgrade ever performed	Upgraded in last 3 years
Trimmed pump impellers	11.8%	5.2%
Installed or modified pump control system	23.7%	18.3%
Redesigned pipe layout to reduce friction losses	49.0%	42.9%
Replaced with higher efficiency pumps	41.8%	34.4%
Increased piping diameter	47.1%	38.6%
Replaced worn impellers or bearings	88.4%	77.0%

1.2.2.4 Gas Process Heating

The gas process heating section was added in Phase 2 at the suggestion of the Project Advisory Committee. Questions about the systems were asked only if the site had at least 10,000 therms/year or $5,000/year in gas bills. The principal findings are provided in Exhibit 1-11.

The data reveal a significant sensitivity to gas-cost management. Over 20 percent of facilities had stack heat recovery and condensate heat recovery on their boilers. Presence of electronic ignition is 31 percent. This indicates a market approaching transformation, as this feature is not applicable to all boilers. Oxygen control (O_2 trim) is used at nearly 14 percent of sites. Survey participants also had an opportunity to report on retrofit-type changes made to the boilers. The most common were reducing the steam pressure and increasing boiler piping and jacket insulation.

Exhibit 1-11. Gas Boiler Energy Efficiency Choices from the 2002–2003 Survey

Questions and Responses	SICs 21-34, 37-39	
	Estimate	Std. Error
Industry gas process heating energy-efficiency options present on boilers		
Stack heat recovery	22.2%	5.5%
Condensate heat recovery	20.9%	5.5%
Other heat recovery	7.5%	4.5%
Automated tuning (O_2 trim control)	13.8%	4.9%
Electronic ignition	31.1%	4.9%
Turbulators for firetube boilers	9.9%	4.8%
Industry gas process heating energy-efficiency options installed on boilers in the last three years		
Stack heat recovery	10.7%	4.8%
Condensate heat recovery	3.0%	1.7%
Other heat recovery	0.0%	0.0%
Automated tuning (O_2 trim control)	1.9%	1.0%
Electronic ignition	11.8%	4.9%
Turbulators for firetube boilers	0.7%	0.7%
Increased pipe and boiler jacket insulation	22.1%	1.3%
Reduced boiler blow-down cycle	3.6%	1.6%
Reduced steam pressure	37.6%	0.7%
Variable speed drives on larger forced-draft and induced-draft fans	2.4%	1.5%
Automatic flue damper	4.3%	2.1%
Smaller boiler for low-load conditions	0.7%	0.7%
Other	0.2%	0.2%

1.2.2.5 Refrigeration

Both phases involved collecting data on refrigeration. The principal efficiency measures investigated were:

- Heat recovery
- Floating-head pressure controls
- Installation of ammonia-based systems
- Use of variable speed drives (VSDs) on cooling-tower fans

Exhibit 1-12 provides the market shares for heat recovery, floating-head, and ammonia-based systems. Refrigeration questions were asked only of sites with at least 20 horsepower of mechanical cooling for other than human comfort. In Phase 1, the questions were only asked of firms in SIC 20 (food and kindred). The use of all of the measures is noteworthy, and ammonia systems had captured much of the market. Since refrigeration costs more as a percentage of revenue for the food industry than for other SICs, and because the food industry is more likely to run large tonnage systems, it is not surprising that they have higher energy-efficiency measure saturations than the broader group of industries surveyed in 2002-2003.

Exhibit 1-12. Market Saturation Ratios for Selected Refrigeration Efficiency Options

Questions and Answers	2001–2002*		2002–2003	
	SIC 20		SICs 21-34, 37-39	
	Estimate	Std. Error	Estimate	Std. Error
Percentage of refrigeration hp with heat recovery	8.8%	4.8%	1.5%	0.4%
Percentage of refrigeration hp with floating head	25.7%	11.1%	4.3%	4.3%
Percentage of refrigeration hp that is ammonia-based	79.6%	6.6%	4.3%	4.3%

* Refrigeration questions were not asked of SIC 35 and 36 respondents in Phase 1.

The incidence of VSDs for cooling tower fans was about 6 percent in both Phases 1 and 2. The high incidence of ammonia systems and floating head in the Phase 1 population is very encouraging. Programmatically, the disparity suggests that conducting case studies on those who have implemented these technologies might be a valuable means to persuade others that these options are cost effective and reliable and deliver a business advantage.

1.2.2.6 Compressed Air

Questions on compressed-air systems were asked at a facility only if the site had systems totaling 50 or more horsepower. Exhibit 1-13 shows that from 33 percent to 40 percent of compressor horsepower in the modulating units were operated in an efficient manner (i.e., used an alternative to throttling). It shows that 6 percent to 8 percent used VSDs, and the rest used other measures.

Exhibit 1-13. Air Compressor Part-Load Control – Other Than Throttling Modulation and Use of Variable Speed Drives

Questions and Answers	2001–2002								2002–2003	
	SIC 20		SIC 35		SIC 36		SICs 20, 35, 36		SICs 21-34, 37-39	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
Percent of modulating compressor hp not controlled by a throttle valve	37.0%	6.3%	25.5%	4.2%	61.5%	4.6%	**40.4%**	3.1%	**33.4%**	12.0%
Percentage of modulating compressor hp controlled by Variable Speed Drive	0.0%	0.0%	2.6%	2.1%	19.4%	1.3%	**7.6%**	0.8%	**5.7%**	1.8%

Exhibit 1-14 shows that approximately 19 percent to 36 percent of compressor horsepower was governed by automatic controls to optimally sequence multiple-compressor operation. Other key findings in the compressed-air portion of the survey included:

- In Phase 1, about 10 percent of facilities switched from electric tools to pneumatic tools and 1 percent switched from pneumatic to electric. This likely represents an increase in energy use. There was no measurable switching among Phase 2 respondents.
- Personnel reported searching for leaks at least annually in about 60 percent of the cases.
- Although firms reported relatively frequent leak searches, only 22 percent to 42 percent reported that they had a comprehensive compressed-air audit performed.

Exhibit 1-14. Air Compressor Part Load Control – Multi-Compressor Sequencing

Questions and Answers	2001–2002								2002–2003	
	SIC 20		SIC 35		SIC 36		SICs 20, 35, 36		SICs 21-34, 37-39	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
Use automatic controls to optimally sequence multiple air compressor operation										
Yes	42.1%	22.1%	19.1%	6.5%	51.6%	5.2%	**35.6%**	7.1%	**19.4%**	6.7%
No	57.3%	22.1%	79.5%	6.5%	38.9%	5.2%	**60.8%**	7.1%	**77.2%**	7.5%
Not Sure	0.6%	NA	1.0%	0.4%	9.0%	NA	**3.3%**	0.2%	**3.4%**	3.3%
Missing	0.0%	0.0%	0.4%	0.4%	0.5%	0.5%	**0.3%**	0.2%	**0.0%**	0.0%

Compressed-air efficiency requires a systems approach. Fixing leaks in one place is unproductive if other inefficient features are in the system. Program opportunity may exist in emphasizing the systems approach, creating manuals or software products, or offering compressed-air audits.

1.2.2.7 Water Recovery and Reuse

About one-eighth of sites surveyed have installed water recovery and reuse systems (Exhibit 1-15). Between 12 percent and 14 percent of plants surveyed had water recovery systems installed. Very few of those featured heat recovery (3 percent to 11 percent). Combined water and heat recovery systems are present at less than 2 percent of all sites. "Environmental reasons" were cited by more respondents (59 percent to 72 percent) than any other reason for installing water recovery systems. Aspen interprets that response to mean U.S. Environmental Protection Agency (EPA) regulatory compliance concerns affected the decision more so than regard to ecology.

Exhibit 1-15. Proportion of Plants with Water Recovery With and Without Heat Recovery

Questions and Answers	2001–2002								2002–2003	
	SIC 20		SIC 35		SIC 36		SICs 20, 35, 36		SICs 21-34, 37-39	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
Proportion of facilities with a water recovery and reuse system	13.3%	5.2%	11.3%	7.9%	19.3%	9.8%	**13.5%**	5.0%	**11.5%**	3.3%
Proportion of wastewater recovery systems that include heat recovery	11.5%	6.4%	0.0%	0.0%	0.0%	0.0%	**2.5%**	1.4%	**10.9%**	10.2%

1.2.2.8 Electronic Control of Process Equipment

Aspen interviewed five electronic process control (EPC) experts prior to site data collection. Participants collectively reported that energy management or load shedding was minimally used in process control. Participants stated that controls are primarily installed for productivity, diagnostics, and quality issues. Energy was not believed to be an important concern.

Other key findings from Aspen's data collection included:

- The percent of sites with electronic controls to unload or turn off equipment when not in use was 13 percent for Phase 1 and 5 percent for Phase 2.
- Load under control (weighted average per site) was 320 horsepower in Phase 1 and 499 horsepower in Phase 2.
- Load that could be dropped under control events was 201 to 228 horsepower (weighted average per site).

1.2.2.9 Power Generation

As the study was conducted during and immediately following the California power crisis of 2000 and 2001, stakeholders were interested in customers' use of and plans for self-generation. Exhibit 1-16 addresses these questions.

Exhibit 1-16. Non-Emergency On-Site Generation

Questions and Answers	2001–2002								2002–2003	
	SIC 20		SIC 35		SIC 36		SICs 20, 35, 36		SICs 21-34, 37-39	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
Proportion with a power supply used regularly to generate electricity	0.2%	0.2%	0.0%	0.0%	3.8%	3.0%	**1.1%**	0.8%	**2.2%**	1.5%
Currently planning on installing additional generation capacity	W	W	W	W	W	W	**W**	W	**1.8%**	1.2%

W = Withheld

Today, fewer than 3 percent of the customers have customer-owned (non-emergency) generation assets and use them regularly to generate electricity for their end-use equipment. In the Phase 2 sample (surveyed in the wake of the crisis), about the same percentage indicated that they planned to install additional generation capacity. Of those that used self-generation, none reported using it for load-management purposes.

The findings in this section have several key implications for planning:

- Based on participants' responses, there will be a doubling of self-generation among manufacturing customers in the foreseeable future.
- None of the participants with self-generation use the generation for load relief. (Note: The number of respondents who routinely use power generation capacity was small compared to the entire survey sample. This subset of respondents constitutes the sample for the load relief questions, therefore, standard errors for this question are large and conclusions based on these results should be made cautiously. Still, a complete absence of peak shaving practices suggests savings potential exists.) There may be potential for the utilities or CEC to purchase load-reduction dispatch rights from the customers and create a demand-reduction resource pool, or to offer incentives for third parties to organize this resource.

Depending on the size and configuration of the customer-owned generating assets, it might be possible for utilities or CEC to arrange them to be synchronous with the power system and to be *dispatchable* generation assets rather than just load-response assets.

1.2.3 Maintenance Practices

The study period encapsulated by the "in last two years" clause of Phase 1 and Phase 2 includes the winter of 2001 and the California energy crisis. Therefore, it comes as no surprise that facilities reported an increase in their efforts on energy-related issues over that period (Exhibit 1-17). Although the majority of facilities responded that maintenance efforts on energy-related issues have stayed the same, the percentage of facilities that reported an increase in maintenance efforts more than doubled from 2001–2002 to 2002–2003. Some of the larger firms are known to have participated in voluntary load reductions, turning non-critical lights and equipment off, rescheduling work to the night shift, and briefly shutting down operations on critical days.

Exhibit 1-17. Energy-Related Maintenance Activities

Question and Responses	2001–2002								2002–2003	
	SIC 20		SIC 35		SIC 36		SICs 20, 35, 36		SICs 21-34, 37-39	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
Over the last two years, has maintenance effort on energy-related issues such as compressed air, blowers, and lubrication, increased, decreased or stayed the same?										
Increased substantially	1.7%	0.9%	0.8%	0.4%	0.4%	0.2%	**0.9%**	0.3%	**2.8%**	1.5%
Increased somewhat	21.6%	8.2%	18.4%	10.0%	16.0%	9.4%	**18.6%**	6.2%	**8.6%**	2.9%
Stayed the same	70.6%	9.1%	76.5%	10.6%	72.2%	10.6%	**74.2%**	6.7%	**87.8%**	3.2%
Decreased somewhat	0.0%	0.0%	0.1%	0.1%	7.8%	4.2%	**1.8%**	0.9%	**0.5%**	0.3%
Decreased substantially	0.0%	0.0%	4.0%	3.7%	0.3%	0.2%	**2.3%**	2.1%	**0.1%**	0.1%
Don't Know	6.1%	6.1%	0.3%	0.3%	3.2%	3.2%	**2.3%**	1.6%	**0.1%**	0.1%

Surveyors also asked questions about maintenance practices on specific types of energy-using systems in the plants, such as compressed air, blowers, motors, and bearings. Respondents were asked to classify their maintenance activities as:

- *As Needed*: Repair/replace on equipment failure or significant loss of performance.
- *Unscheduled Preventative*: Service items on an ad-hoc basis at signs of trouble or check intermittently using rules of thumb to spot problems.
- *Limited Scheduled Preventative*: Follow a pre-determined maintenance schedule for all major systems and equipment.
- *Aggressive Preventative*: Maintain most or all equipment on a predetermined schedule. Track with computer program. May be done by internal or outside contractor.
- *Predictive*: Monitor times and cycles of equipment using built-in monitoring devices, deploy predictive models to anticipate maintenance problems.

The maintenance policy data reflect the following observations:

- "As needed" is the largest category chosen in both phases, indicating there remains much opportunity for improving maintenance practices.

- The percentages were similar between the 2001–02 and the 2002–03 groups.
- "Predictive" maintenance is rare.

It is not clear whether the increased attention to maintenance was due to the energy crisis or to the fact that different industries were surveyed in the two phases. We suspect that the energy crisis was the larger driver of the observed results.

Participants were also asked about maintenance training. The results from these questions show that the commitment to training maintenance personnel on energy related matters tripled in Phase 2 compared with Phase 1. This could be an instance where the change is due to timing of the survey—Phase 2 followed the power crisis and Phase 1 was during it—rather than differences between SICs.

Exhibit 1-18 summarizes the responses to questions regarding maintenance policy and training activities. The ranges represent the variation over different technologies for which the policy questions were asked.

Exhibit 1-18. Maintenance Policy and Training Activities

Maintenance Policy:	**Percentage of Responses By Maintenance Practice and SIC**	**Maintenance Practice with Highest Percentage**
As Needed	18% to 61%	Motor belt replacement
Unscheduled Preventive	1% to 6%	Filters
Limited Scheduled Preventive	9% to 35%	Motor lubrication
Aggressive Preventive	6% to 23%	Motor lubrication
Predictive	0% to 2%	Steam traps and pressure regulators

Training In Past Two Years on Energy Topics :	**Phase 1 (2001-2002)**	**Phase 2 (2002-2003)**
Yes	7%	23%
No	93%	76%

1.2.3.1 General Information

At the start of each interview, participants were asked general information questions. Two types of general information were solicited: (1) firmographic data (e.g., size of facility—expressed in terms of floorspace, employment, shift operations, and energy use—and business activity trends); and (2) results that give indicators or energy-efficiency market share or practices that are not associated with any of the industrial technologies listed above. Based on these questions, the following principal findings included:

- The frequently cited problem of financial disconnect between those who order equipment and those who pay the bills did not fully hold up. About 45 percent of the sites stated that the department specifying the equipment also paid the bills.

- In Phase 2 (2002–2003), participants were asked if production had increased or decreased in the past three years. Thirty-two percent reported an increase in overall production, despite the very slow economy for that the period.
- Phase 2 solicited information on building size (square feet). The median size of industrial buildings was reported to be between 10,001 and 25,000 square feet. (The same size categories used by the United States Department of Energy's Commercial Buildings Energy Consumption Survey were used for the study.)

1.2.3.2 Market Channels

Facility managers were asked to provide information on how they learn about energy efficiency. By knowing what channels are most frequently used, program designers can optimize information/marketing resources and target audiences.

Exhibit 1-19 highlights the marketing channels used to learn about energy efficiency in regard to motors, compressed air, electronic process control, wastewater recovery, and power generation.

Exhibit 1-19. Marketing Channels

Question and Responses	Motors	Compressed Air	Wastewater Recovery	Electronic Process Control	Power Generation
How do you become aware of new products and product improvements?			(Ph 2 only)	(Ph 2 only)	(Ph 2 only)
Read about them in trade journals	48%	3%	59%	89%	72%
Sales Personnel	44%	34%	33%	50%	10%
Utility/staff programs	6%	3%	8%	25%	1%
Business associates	9%	4%	6%	32%	1%
Trade shows	7%	NA	12%	34%	3%
Training	NA	NA	3%	27%	1%
Paid Consultants	NA	NA	2%	26%	0%
Other	10%	3%	8%	25%	0%
Not sure	1%	1%	19%	0%	0%

1.3 Recommendations

The objective of the tracking study was to collect and analyze data on the California industrial sector in the first three years of the 21^{st} century. Based on the large volumes of data obtained, it is apparent that this objective was achieved. Much analysis can be done on these data to offer insights for program design and evaluation. The study also involved analysis of limited topics. Following is a list of the principal energy-efficiency program opportunities identified, as well as recommendations:

- Training and information for lighting professionals may be an effective way to increase the use of daylighting technologies, which is between 0 percent to 20 percent based on responses by lighting designers interviewed.
- T8 technology is underused in industrial settings (12 percent), compared to "all commercial" facilities (52 percent to 55 percent). Incentives and other programs aimed at industrial retrofit are recommended.
- Expand industrial training offerings.
- Increase premium-efficiency motors awareness and promotion programs to improve understanding of the meaning of premium-efficiency and to gain a larger market share.
- Develop programs that target end-user purchasing personnel and manufacturers' advertising personnel. Drive demand for premium motors by training private and public procurement personnel to seek packaged equipment that features premium-efficiency motors.
- Encourage packaged-equipment manufacturers to feature NEMA premium-efficiency motors in the packaged equipment offered in the market.
- Establish quality standards and standardized diagnostics for motor rewinding to improve rewind practices and promote premium-efficiency motors.
- While a program to promote the retrofit installation of auto-lubrication systems is not advisable, these systems should be promoted as an option to specify when new equipment is purchased.
- Gas boiler heat recovery is underused. Expanding education and offering incentives may increase its use.
- Promote ammonia refrigeration systems to a broader group of industries, in addition to the food industry.
- Compressed-air system optimization remains an opportunity for energy efficiency, especially system maintenance and controls. Program opportunities may exist in emphasizing the systems approach, creating manuals or software products, or offering compressed-air audits.
- Support water reuse with heat recovery where feasible.
- Continue tracking studies to develop and maintain time-series data related to the key findings of this project.

Notes

[1] The group was made up of the former California Board for Energy Efficiency, the California Public Utilities Commission, the California Energy Commission, San Diego Gas and Electric, Southern California Edison, and Pacific Gas and Electric

[2] Database for Energy Efficiency Resources (DEER) Update Study, Xenergy, 2001

[3] Non-Residential New Construction (NRNC) Baseline Study, RLW Analytics, Inc., 1999

[4] California Residential Efficiency Market Share Tracking Study, RER, 2000

[5] California Institute of Food and Agricultural Research Survey on Energy Management in the Food Industry, U.C. Davis, 1999

[6] C&I New Construction and Retrofit Lighting Design and Practices, HMG, 2000

2. Introduction

2.1 Project Goals

Intended to be a long-term tracking effort, the goal of the Nonresidential Market Share Tracking Study was to collect data that will enable the assessment and evaluation of nonresidential markets for energy-using or energy-saving equipment, materials, and practices in California. The data would be used for evaluation of energy efficiency market transformation efforts and the effectiveness of individual programs, as well as for strategic planning purposes.

The California Energy Commission (CEC) managed the project on behalf of the California Public Utilities Commission (CPUC) using California Public Goods Charge Energy Efficiency and Gas Demand Side Management Funds collected by CPUC. Other major stakeholders included Southern California Edison (SCE), Pacific Gas and Electric (PG&E), San Diego Gas and Electric (SDG&E), and Southern California Gas Company (SCGC).

After CEC awarded Aspen Systems Corporation the contract to conduct the tracking study, Aspen met with CEC and utility representatives to discuss data collection strategies. In concert with CEC and the utility representatives, Aspen developed data collection plans for packaged air conditioning, lighting, windows, energy management systems, chillers, motors, compressed air systems and optimization, blowers, automatic lubrication systems, water recovery and reuse, electronic process controls, maintenance, fluid process pumping, and gas process heating. In addition to data on market shares, quantities, and prices of energy-efficient vs. inefficient technologies, CEC expressed particular interest in obtaining data on market characterization attributes, including market pathways and decision factors.

This report details the development and execution of those data collection plans, as well as the processing of the data into summary statistics and the development of databases to house and allow easy access to the raw collected data and summary statistics.

2.2 Project Approach

2.2.1 Data Sources Overview

Data collection was organized into three major tasks:

- Collection of data from secondary sources
- Conducting surveys on site at industrial production facilities
- Interviewing upstream market actors, including manufacturers, distributors, installers, and designers

Secondary data collection focused on lighting, windows, energy management systems, and chillers. For this task, Aspen evaluated data from secondary sources, including California Measurement Advisory Council (CALMAC) reports, California Board for Energy Efficiency (CBEE) studies, trade journals, and the Internet for relevance to the tracking study. Aspen obtained data from the Database for Energy Efficiency Resources (DEER) Update Study, Non-Residential New Construction Baseline Study, California Residential Efficiency Market Share Tracking Study, California Institute of Food and Agricultural Research Survey on Energy Management in the Food Industry, California Residential Efficiency Market Share Tracking Study, and C&I New Construction and Retrofit Lighting Design and Practices.

An ongoing component of the tracking study was the Industry Energy End-User Survey that Aspen conducted from 2001–2003. In Phase 1, Aspen collected market-oriented, energy-policy relevant data on electric motors, compressed air systems and optimization, blowers, maintenance, water recovery and reuse, electronic process controls, refrigeration, power generation, and general data on plant operations through on-site surveys at manufacturing facilities. For Phase 1, Aspen focused on three industries:

- SIC 20, food and kindred
- SIC 35, industrial and commercial machinery and computer equipment
- SIC 36, electronic and other electrical equipment and components

In Phase 2, Aspen collected data on the same broad technology areas that were examined in Phase 1, as well as on fluid process pumping, gas process heating, and limited data on lighting. Phase 2 covered manufacturing SICs not covered in Phase 1.

Surveys with upstream market actors are also intended as an ongoing component of the tracking study. In the first iteration, Aspen conducted telephone interviews with distributors, manufacturers, installers, and designers to collect data on market shares of energy-efficient lighting, windows, and chillers products. During these interviews, Aspen also collected data on market pathways and other market characterization attributes.

2.2.2 Analysis Overview

Summary statistics are required to track market changes over time. Aspen estimated market shares of energy-efficient products bought, percentages of market actors applying various decision factors, average prices and price differentials for energy efficient vs. inefficient products, statistics illuminating market pathways, as well as other market-characterization attributes. Estimated standard errors for all estimates for which raw data were available were computed providing a measure of data reliability and integrity.

2.2.3 Construction of Databases

Aspen created two Microsoft ACCESS databases to house the data that were gathered and analyzed. The tracking study's Confidential Database houses data gathered from individual surveys of market actors. Names, addresses, and other data that would directly identify the respondent or responding establishment are not included in the database. The tracking study's Public Database contains summary statistics derived from the data in the Confidential Database, as well as publicly available data collected from other sources. Query screens help to facilitate the location of data of interest to the user.

2.3 Report Organization

The remainder of this report is organized as follows:

- Chapter 3 discusses the principal results of the tracking study, including results and analysis from secondary sources, on-site surveys, and upstream market actor surveys.
- Chapter 4 focuses on all the underlying sampling, data collection, and analytical methodologies used to produce the results presented in Chapter 3 and stored in the tracking study's databases.
- Chapter 5 explains how to use the tracking study's Public Database application.
- Chapter 6 explains database development and structure.

Additionally, there are 11 technical appendices provided as Volume II of the report:

- Appendix A. Phase 1 Industry Energy End-User Survey
- Appendix B. Phase 2 Industry Energy End-User Survey
- Appendix C. Upstream Market Actor Telephone Survey Questionnaires
- Appendix D. Data Dictionary: Public Database
- Appendix E. Report on Industrial Technology Supplier/Expert Pre-Survey Interview Results
- Appendix F. Secondary Sources Bibliography
- Appendix G. Phase 1 Phone Recruiting Survey Instrument
- Appendix H. Phase 2 Phone Recruiting Survey Instrument
- Appendix I. Phase 1 List of Quality Control Checks
- Appendix J. Phase 2 List of Quality Control Checks

3. Principal Results

3.1 Introduction

Several exhibits containing data collected during the tracking study are provided in this chapter. These results highlight data pertaining to key industries and technologies in the tracking study.

Data for three technologies—lighting, chillers, and windows—that are used extensively in commercial and industrial buildings is provided in Section 3.2. For each technology, secondary and primary data are provided. Aspen reviewed and analyzed relevant secondary data that were collected and compiled by other sources.

The following six sources provided highly relevant data for the tracking study and Public Database:

- Nonresidential New Construction (NRNC) Baseline Study, 1999
- California Institute of Food and Agricultural Research Survey on Energy Management in the Food Industry, 1999
- California Residential Efficiency Market Share Tracking Study, 2000
- C&I New Construction and Retrofit Lighting Design and Practices, 2000
- Database for Energy Efficiency Resources (DEER) Update Study, 2001
- HVAC Residential Market Share Tracking Study, 2002

A complete list of the 38 secondary sources that Aspen reviewed is provided in Appendix F.

In addition to reviewing and analyzing secondary data, Aspen collected primary data on lighting, chillers, and windows via 104 telephone interviews with five groups of upstream market actors—manufacturers, dealers, suppliers, designers, and contractors. A copy of the questionnaire used for each group is provided in Appendix C.

Section 3.3 contains study results specific to the industrial sector—mostly related to industrial process operations. These results are based on primary data collected during Aspen's Industry Energy End-User Survey from a stratified random sample of 560 manufacturing plants.

3.2 Commercial and Industrial Applications

3.2.1 Lighting

3.2.1.1 Lighting Data from Secondary Sources

Exhibit 3-1 provides an example of data included in the Public Database that was created using secondary data. Provided is a summary of lighting market share estimates that Aspen developed from data compiled by the NRNC. More than 4,000 lighting market share estimates contained in the Public Database were used to generate this exhibit. Standard errors for the estimated market shares were computed and are shown in parentheses.

Exhibit 3-1. Selected Lighting Results from Public Database

1999 Non-Residential New Construction Baseline Study

Estimated Market Share for Lighting Technologies in Non-Residential New Construction

Utility Selected: PG&E/SCE/SDGE

Building	Technology	1994	1995 (SDGE only)	1996	1998
All Buildings					
	Compact Fluorescent	3.03%	3.30%	3.59%	3.56%
	Standard Error:	(0.49%)	(1.14%)	(0.51%)	(0.52%)
	T12 Electronic Ballast	8.42%	7.42%	3.45%	0.72%
	Standard Error:	(1.77%)	(6.77%)	(1.14%)	(0.40%)
	T12 Magnetic Energy Saver Ballast	13.11%	1.59%	10.17%	5.95%
	Standard Error:	(2.20%)	(1.16%)	(2.68%)	(3.25%)
	T12 Magnetic Standard Ballast	11.74%	14.86%	5.48%	2.71%
	Standard Error:	(2.59%)	(6.46%)	(2.18%)	(1.31%)
	T8 Electronic Ballast	30.75%	46.83%	40.74%	52.41%
	Standard Error:	(4.34%)	(11.66%)	(3.13%)	(5.40%)
	T8 Magnetic Energy Saver Ballast	3.58%	0.03%	2.90%	1.36%
	Standard Error:	(1.08%)	(0.02%)	(1.08%)	(1.01%)

Note: 1995 results should be used with caution. The sample was all in the SDG&E territory and there were only 30 observations.

This exhibit indicates that the share of efficient technology in the lighting market is growing, specifically:

- Compact fluorescent lights (CFLs) were about 3.5 percent of the market in 1998. This percentage is higher than the current estimated national average of 2.5 percent, which was provided by a representative of a large lighting manufacturer who was interviewed as part of the research with upstream market actors.

- The CFL market share increased from 3 percent in 1994 to 3.5 percent in 1998. The magnitudes of the standard errors are such that this apparent growth might not be actual. Additional data from 2000 or 2001 is needed to clarify the situation.
- T12 technology, across all three lamp-ballast combinations, has decreased steadily, from 33 percent market share in 1994, to 19 percent in 1996, to 9 percent in 1998.
- T8 lamp/electronic ballast systems, the acknowledged efficiency choice, increased from 31 percent in 1994, to 41 percent in 1996, to about 52 percent in 1998.
- The more than 20 percent decline in T12 lamp market share over four years was matched almost identically with a more than 20 percent increase in the share of T8 lamps over the same period.

Another example of the types of reports that can be generated from the Public Database is provided as Exhibit 3-2. The report was generated for three lighting technologies and three building types for the combined service territories of PG&E, SCE, and SDG&E. Aspen discovered that in the office building type, the market share of T12 magnetic ballast lighting continued to decline from less than 5 percent in 1994 to around 1 percent by 1998, while the market share for the more efficient T8 electronic ballast technology has increased from 62 percent in 1994 to 74 percent in 1998. The market share of T8 lamps grew increased minimally between 1996 and 1998, suggesting a plateau or possibly market saturation of T8 systems.

A third example of secondary data used was the Study of C&I New Construction and Retrofit Lighting Design and Practices, which was commissioned by the Sacramento Municipal Utility District (SMUD) to provide a market-characterization assessment of SMUD's services relative to the rest of the state. Key objectives of the survey were to:

- Develop a baseline of current lighting design and retrofit practices for commercial and industrial customers.
- Conduct a market assessment of commercial and industrial lighting market.
- Compare the SMUD situation with that in other parts of California.
- Present recommendations for future direction.

The study conducted telephone surveys with a range of key market actors, including:

- Manufacturers and distributors
- Lighting design community members
- Building officials
- Owners and developers
- Property managers

Key findings of the report were:

- Major market players are owners/developers, designers, manufacturers' representatives.
- SMUD's lighting programs are consistent with those of other utilities in region.
- Market share of T8 lamps and electronic ballast in the commercial market range from 50 percent to 75 percent with penetration of 75 percent to 80 percent for new construction.

- The market for T8s in new construction has been transformed.

Exhibit 3-2. Sample Output Report for NRNC Lighting Technology Market Shares

1999 Non-Residential New Construction Baseline Study

Estimated Market Share for Lighting Technologies in Non-Residential New Construction

Utility Selected: PG&E/SCE/SDGE

Building	Technology	1994	1995	1996	1998
C&I Storage					
Metal Halide		10.03%		63.66%	
	Standard Error	(6.30%)	( )	(11.51%)	( )
T12 Magnetic Standard Ballast		10.02%		5.68%	
	Standard Error	(4.03%)	( )	(5.25%)	( )
T8 Electronic Ballast		22.54%		12.28%	
	Standard Error	(18.24%)	( )	(2.78%)	( )
Office					
Metal Halide		1.22%	0.31%	4.55%	1.47%
	Standard Error	(0.49%)	(0.31%)	(1.55%)	(0.75%)
T12 Magnetic Standard Ballast		4.76%	20.64%	0.66%	1.50%
	Standard Error	(2.96%)	(15.89%)	(0.53%)	(0.91%)
T8 Electronic Ballast		62.20%	62.13%	70.10%	73.86%
	Standard Error	(6.08%)	(13.37%)	(4.32%)	(7.33%)
Retail					
Metal Halide		16.74%	33.72%	20.61%	51.23%
	Standard Error	(6.45%)	(20.99%)	(5.63%)	(7.23%)
T12 Magnetic Standard Ballast		9.21%	7.37%	0.74%	2.12%
	Standard Error	(5.09%)	(6.55%)	(0.41%)	(0.63%)
T8 Electronic Ballast		28.93%	11.17%	38.31%	28.06%
	Standard Error	(10.57%)	(8.20%)	(5.48%)	(6.99%)

Note: 1995 results should be used with caution. The sample was all in the SDG&E territory and there were only 30 observations.

Three data tables were extracted from this study and are included in the Public Database. The data can be accessed by first selecting **Lighting** from the main database technology selection screen, then selecting **Lighting Market** to proceed to the data selection screen. The following three selection options are then available:

- Percent of New Construction Projects with T8/Electronic Ballast

- Retrofit Projects with T8/Electronic Ballast
- Use of T8/Electronic Ballast in Meeting Title 24

Exhibit 3-3 provides an example of the output report when a user selects **Percent of New Construction Projects with T8/Electronic Ballasts**. This report quantifies major market actors' responses when asked what percentage of the projects on which they have worked used T8/electronic ballasts at varying concentrations. For example, 87 percent of the 27 distributors/manufacturers surveyed reported that T8/electronic ballasts were used more than 75 percent of the time in the projects they worked on. It is interesting to note that the industry experts (distributors, designers, building officials, and developers) are reporting a high use of T8/electronic ballasts, but 60 percent of non-experts (property managers) stated that they did not know the technology being used.

Exhibit 3-3. Sample SMUD Study Output Report

2000 New Construction and Retrofit Lighting Design and Practices Study

Percent of New Construction Projects with T-8/Electronic Ballast Fixtures

	General Lighted Floor Area							
	More Than 75%	More than 50%	Less than 25%	Don't Know	Total	Sample Size	Response Rate	Standard Error
Distributor/Manufacturer	87.00%	4.00%	4.00%	4.00%	99.00%	27	84.38%	Not Reported
Designer	87.00%	4.00%	4.00%	4.00%	99.00%	23	60.53%	Not Reported
Building Official	86.00%	14.00%	0.00%	0.00%	100.00%	7	77.78%	Not Reported
Owner/Developer	75.00%	13.00%	0.00%	13.00%	101.00%	8	34.78%	Not Reported
Property Manager	40.00%	0.00%	0.00%	60.00%	100.00%	5	25.00%	Not Reported

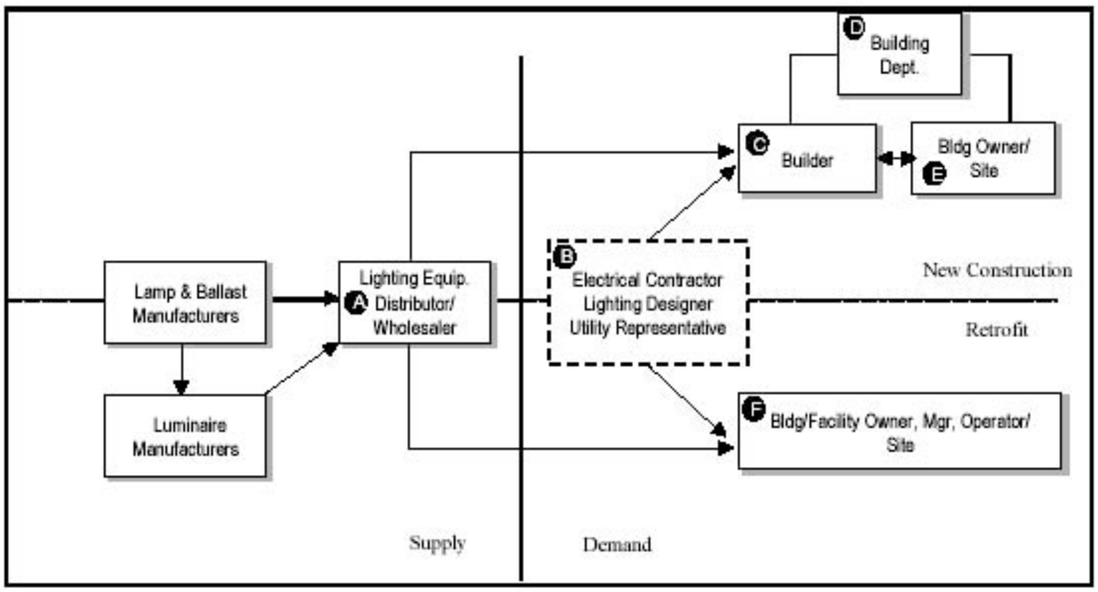
3.2.1.2 Lighting Data from Primary Research With Upstream Market Actors

The Public Database enables users to select, view, and print results from data analyses (i.e., means or proportions), plus the corresponding standard errors, of data developed from the telephone surveys with three upstream market actor categories: lighting distributors and wholesalers, manufacturers, and designers. The firms selected for the sample for each category spanned a wide range of business types and sizes. In the case of designers, the respondents included representatives from small lighting-design consultants to large architect-engineers to electrical contractors. Some examples of the data provided in the Public Database are shown below. In several instances, Aspen's "findings" and interpretation of the data and information obtained via the upstream market actor surveys are provided.

Market Pathways and Roles of Key Decision-Makers

The current study's description of market pathways differs from the description provided in the Efficiency Market Share Needs Assessment and Feasibility Scoping Study[1] in its focus. This scoping study acknowledges that it provides a "simplified view of the distribution channels for commercial lighting equipment" when referring to its Figure 4-13, which appears as our Exhibit 3-4.

Exhibit 3-4. Scoping Study Representation of Market Pathways for Nonresidential Lighting Equipment



Source: Figure 4-13 on page 4-47 of Efficiency Market Share Needs Assessment and Feasibility Scoping Study

The following text follows this figure in the scoping study report:

> "The market for T8 lamps with electronic ballasts has some interesting characteristics that should be taken into account with respect to market share tracking. First, as indicated in Figure 4-13, tracking data could be collected from distributors (node A), contractors (node B), from building departments (node D), or at the site level (nodes E and F). Second, and more importantly, evidence suggests that the market for T8s with electronic ballasts has been transformed. As explained above, recent Title 24 revisions pertaining to lighting are based upon the assumption of T8s with electronic ballasts, as a means of "catching up with what is becoming common practice."[2] Several interviewees also commented that the market for T8s with electronic ballasts is "mature." Tracking a high efficiency measure that has already been widely adopted in the marketplace has both advantages and disadvantages. Although this measure was identified as a priority by interviewees in the Needs Assessment phase of this study, tracking T8s with electronic ballasts might not be a productive use of funding. In other words, there is an opportunity cost associated with committing funding for a measure whose market is fairly mature. On the other hand, tracking T8s with electronic ballasts provides an opportunity to ascertain sustainability in the marketplace in a relatively short period. Has this market *truly* been transformed?"

Aspen's market actor research examined the interactions among the decision-makers involved in ***recommending the lighting-equipment choices*** that produce the flow of energy-efficient lighting equipment through market channels. In short, one of Aspen's goals was to identify and characterize the market actors who play a significant role in prompting decisions to purchase energy-efficient lighting equipment.

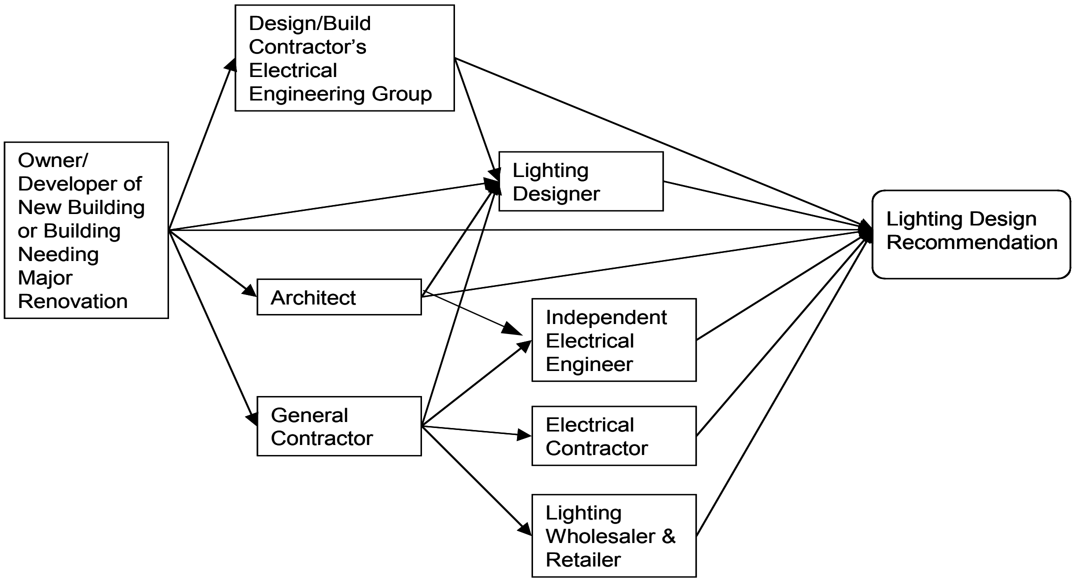
The "real-world" lighting market has multiple points at which energy-efficient lighting designs can be recommended. There is no single player who makes these decisions, therefore, selecting one or two of these points as targets for energy-efficient lighting outreach will miss a significant share of the nonresidential market. This is true for the new construction and the renovation/retrofit markets.

Telephone interviews with upstream market actors tended to be highly conversational, with respondents often providing information about the way purchase recommendations are made, as well as the individual responsible. Comments often went beyond the explicit questions listed on the questionnaires. Comments were captured and noted in the margin space of the survey instrument.

This qualitative analysis process can serve a useful purpose. It offers a better understanding of the roles and relative importance of the various "gatekeepers" who make recommendations that prompt the decision to purchase more-efficient lighting products and to incorporate electricity-saving lighting design features in building designs.

Exhibit 3-5 illustrates the various market pathways through which authority to make the lighting choices can flow. While the owner always has the final responsibility for approving the recommended choice, most of the time, the owner defers to the recommendation of an "expert" (the last individual or organization in the flow leading to the lighting recommendation).

Exhibit 3-5. Flow of Authority for Recommending the Lighting Equipment for Nonresidential Buildings



As is illustrated, the "expert" on whom the owner relies for a lighting recommendation may be any of six upstream market actors. Each owner has a specific "design team" with whom he/she works and a particular way of soliciting design recommendations in various areas (lighting, HVAC). The design team consists of individuals who possess different technical specialties. The key to producing energy-efficient designs is to ensure that the different market actors thoroughly understand the cost effectiveness, advantages, and availability of all new lighting technologies.

Exhibit 3-6 shows lighting wholesalers and distributors, manufacturers, and designers estimates of revenues, and hence their sales, for products and services from customers in the new construction and renovation/retrofit markets.

Exhibit 3-6. Responses of Three Lighting Market Actor Segments to: "Please estimate the percentages of revenue you receive from sales to the new construction and the renovation/retrofit markets"

Market Actor Segment / Product Or Service	New Construction		Renovation/ Retrofit	
	Estimate	Std. Error	Estimate	Std. Error
Wholesalers & Distributors [n=19]:				
Lighting Equipment Sales*	32.3%	4.9%	67.7%%	8.9%
Lighting Manufacturers [n=4]:				
Lamp Sales*	41.7%	12.6%	58.3%	15.4%
Ballast Sales*	40.6%	14.0%	59.4%	17.2%
Lighting Designers [n=23]:				
Design Services Sales	69.6%	4.8%	30.4%	4.8%

* Data inferred from question, "Please estimate the percentages of revenue you receive from sales to four market segments: Existing NR buildings, New NR buildings, Residential, Industrial, Other"

The two segments, wholesalers and distributors and lighting manufacturers, that reported lighting equipment sales show close agreement, with more revenue coming from the renovation/retrofit market. The revenue split for lighting designers is markedly tilted toward the new construction market. This is to be expected as a portion of the renovation/retrofit market is replacement-in-kind and does not require design services. For example, an efficiency upgrade that replaces T12 lamps and magnet ballasts with T8 lamps and electronic ballasts generally involves little or no design efforts.

Exhibit 3-7 shows lighting equipment wholesalers and distributors estimates of revenues, and hence sales for products and services, to various types of customers.

Exhibit 3-7. Responses of Lighting Equipment Wholesalers and Distributors (n=17) to: "Please estimate the percentages of revenue you receive from sales to various types of customers"

Type of Customer	Estimate	Std. Error
Electrical Contractors	33.6%	8.4%
Facility Owners/Managers	25.5%	6.4%
Builders (New Construction)	5.0%	2.2%
Energy Service Companies	1.1%	0.8%
Designers and Specifiers	9.3%	3.8%
General Public	6.0%	4.8%
Other	19.5%	7.9%

Exhibit 3-8 shows lighting equipment wholesalers and distributors estimates of distribution of the dollar value of lighting products they buy from various sources.

Exhibit 3-8. Responses of Lighting Equipment Wholesalers and Distributors (n=19) to: "Please estimate the percentages of the dollar value of lighting products you buy from various sources"

Source of Products	Estimate	Std. Error
Lamp and Ballast Manufacturers	35.9%	5.3%
Luminary Manufacturers	41.0%	6.6%
Specialty Manufacturers	13.5%	4.2%
Other	3.5%	3.6%

Exhibit 3-9 shows the responses of lighting equipment manufacturers when asked to provide estimates of their revenues from sales of lamps to various types of customers. A similar question asked about revenues from ballast sales, but there was an insufficient number of responses to permit a valid analysis of the data.

Exhibit 3-9. Responses of Lighting Equipment Manufacturers (n=4) to: "Please estimate the percentage of revenues you receive from sales of lamps to various types of customers"

Type of Customer	Estimate	Std. Error
Wholesalers and Distributors	45.4%	21.7%
Lighting Fixture OEMs	24.4%	11.7%
Electrical Contractors and Installers	5.4%	5.9%
Other	24.9%	23.2%

Exhibit 3-10 shows the responses of lighting designers when asked to provide estimates of their revenues from design services provided to various types of clients.

Exhibit 3-10. Responses of Lighting Designers (n=17) to: "Please estimate the percentages of revenue you receive from providing design services to various types of clients"

Type of Client	Estimate	Std. Error
Building Owners/Developers	25.3%	4.6%
Tenants	5.1%	2.3%
General Contracting Firms	12.2%	8.0%
Other (Most often Architects)	57.4%	8.8%

Market Shares and Prices of Energy-Efficient Features and Equipment

Despite repeated calls, California-specific "hard data" related to either market shares or prices of energy-efficient lighting equipment could not be obtained from any of the lighting equipment manufacturers. However, a representative of one of the major U.S. lamp manufacturers provided the following estimates:

T8 vs. T12: T8 fluorescent lamps have captured about 55 percent of the overall California market, compared with 45 percent market penetration for T8 lamps in the overall U.S. market. This statement is consistent with the Public Database ratio of 52 percent found in the NRNC study for all buildings in all areas in 1998 (Exhibit 3-1).

CFL vs. incandescent: Eight major manufacturers sell about 50 million CFL units vs. about 2 billion incandescent lamps per year nationwide. Less costly and lower quality "import" versions of CFLs are also starting to infiltrate the U.S. market, especially in California. The eight U.S. manufacturers sell about 10 million to 15 million CFL units per year in California. These data reflect sales in the residential and nonresidential sectors. This estimate indicates that the CFL share for the United States is on the order of 2.5 percent, which is 50 million in a market of 2 billion.

If it is assumed that CFL sales in California were 15 million (upper side of provided estimate of 10 million to 15 million) and total lamp sales were about 400 million (20 percent of the 2 billion national lamp sales reported), the CFL share for California was about 3.8 percent. This would lead to a CFL share in California of 15 million out of 400 million, or 0.0375. This is 150 percent of the national average, reflecting the progress of California's energy-efficiency programs. This data point is consistent with the 3.6 percent CFL market share estimate derived by Aspen from the NRNC study for 1998 (Exhibit 3-1). Finally, it suggests that shares have not changed materially since 1998, for reasons potentially including a slowdown in energy efficiency owing to the advent of utility-industry restructuring.

Less than two lighting equipment wholesalers and distributors provided sales volume and price data for any item of lighting equipment. This was judged to be too small a sample to provide meaningful population estimates.

The lighting designers reported data concerning how often their designs incorporate nine specific energy-efficient features. Exhibit 3-11 presents these results. Some of the noteworthy conclusions are:

- Task lighting is used at least half the time in two-thirds of designs, and is always used in about 14 percent of designs.
- More than half of the designers specify dimmable ballasts in at least half of their projects.
- Nearly 80 percent of designers incorporate CFLs either most or all of the time.
- Daylighting is not yet a commonly used energy-efficiency design feature.

These findings indicate the need for additional training and education for professionals on the value of using architectural elements, such as daylighting, to reduce the need to use as much electricity for lighting.

Exhibit 3-11. Responses of Lighting Designers to: "How often do your designs incorporate certain energy-efficiency features?"

Energy-Efficiency Feature	n	Never	Some-times	About half the time	Most of the time	Always
Task Lighting Standard Error	23	13.2% (7.5%)	20.4% (8.9%)	39.0% (11.3%)	13.6% (7.9%)	13.8% (7.3%)
Full (uniform) Space Illumination Standard Error	22	0%	10.4% (6.5%)	8.5% (6.5%)	24.1% (10.0%)	57.0% (11.5%)
Dimmable Ballasts Standard Error	23	17.0 (9.0%)	28.7% (10.4%)	30.4% (10.3%)	24.0% (9.2%)	0%
CFLs Standard Error	23	0%	0%	22.9% (10.1%)	28.9% (10.2%)	48.2% (11.3%)
Daylighting, Using:						
- Light Pipes Standard Error	23	78.5% (8.9%)	21.5% (8.9%)	0%	0%	0%
- Skylights Standard Error	23	34.6% (11.0%)	32.3% (10.7%)	18.2% (8.5%)	14.9% (7.5%)	0%
- Windows and Transoms Standard Error	21	26.2% (10.7%)	33.8% (11.5%)	20.2% (9.3%)	15.7% (8.2%)	4.1% (4.2%)
- Other: Light Shelves or Sensors & Controls Standard Error	13	24.9% (13.2%)	41.1% (14.7%)	18.3% (12.1%)	15.8% (11.0%)	0%

Customer Preferences, Decision Factors, and Barriers

Exhibit 3-12 illustrates lighting designers responses to questions regarding how often they propose designs or technologies to clients that result in lower lighting power density than is required by energy-efficiency regulations and how often clients rejected these proposals.

Exhibit 3-12. Responses of Lighting Designers (n=23) to: "How often do you propose designs or technologies to clients that result in lower lighting power density than is required by energy-efficiency regulations, and how often do clients reject these proposals?"

Response	Estimate	Std. Error
Proposals Made:		
Fairly Often	15.2%	10.1%
Sometimes	30.0%	13.6%
Rarely or Never	54.8%	14.7%
Proposals Rejected:		
Fairly Often	2.1%	1.9%
Sometimes	17.6%	10.7%
Rarely or Never	25.5%	13.3%

Lighting designers reported data concerning features that are often requested by clients during the initial stages of lighting design and features that are often eliminated later in the process. Exhibit 3-13 presents these results.

Exhibit 3-13. Responses of Lighting Designers (n=23) to: "What features do clients often request during the initial stages of lighting design and which are often eliminated later in the process?"

Design Feature	Initially Requested		Later Eliminated	
	Estimate	Std. Error	Estimate	Std. Error
Bright Light	12.9%	7.2%	1.7%	1.8%
Natural Color	47.3%	14.7%	1.7%	1.8%
Control Over Individual Fixtures	42.4%	14.7%	26.9%	13.3%
Control Over Lighting Levels	78.9%	11.4%	35.4%	14.6%
Low Energy Use	99.7%	0.4%	20.6%	12.9%
Low Operating Costs	78.7%	12.9%	10.6%	9.9%
Low Maintenance Costs	84.5%	10.6%	2.1%	1.9%
Fancy Architectural Styling*	89.0%	9.9%	19.7%	10.9%
Daylighting	66.1%	13.7%	12.0%	10.0%
Minimum First Cost	49.4%	14.8%	0.0%	0.0%
Other (Requested)**	54.1%	14.7%	N/A	N/A
None Eliminated	N/A	N/A	0.0%	0.0%

* Beyond lobbies and entrances
** "Other (Requested)" consisted of the following features:

Color Systems (2 respondents)
Beauty, Balance, Color, Contrast
Marketing at Night
Creativity
Consistency with Theme
Quality (uniform, glare free,) (2 respondents)
Skylights for Warehouses
Low light levels for viewing computers

When asked if clients for new construction projects had different preferences or objectives than clients for renovation/retrofit projects, more than 72 percent of lighting designers stated this was not the case (Exhibit 3-14).

Exhibit 3-14. Responses of Lighting Designers (n=23) to: "Do clients for new construction projects seem to have different preferences or objectives than clients for renovation/retrofit projects?"

Response	Estimate	Std. Error
Yes	27.1%	12.1%
No	72.6%	12.1%
No Opinion	0.4%	0.4%

Respondents who answered “Yes” were asked to provide details of their perceived differences. Responses included:

- Renovation/retrofit clients want lower initial cost.
- Renovation/retrofit clients are more:
    - Interested in energy savings.
    - Concerned about energy efficiency.
    - Concerned about payback period.
    - Concerned about maintenance efficiency.
- Renovation/retrofit clients often want to maintain the existing lighting style.
- If a renovation/retrofit project involves a “noteworthy” building, clients tend to insist upon architectural integrity and show a commitment to maintaining the style of the building.
- New construction clients are more willing to invest in new technologies.

3.2.2 Chillers

3.2.2.1 Chiller Data from Secondary Sources

The NRNC database contains data on a sample of 156 chillers installed in the new construction market from 1994 through 1998. To present the data in a meaningful manner in the Public Database, Aspen stratified the data by chiller type and size. Additionally, Aspen created three efficiency levels to enhance the presentation of the data.

Establishing efficiency levels presented an interesting challenge. Typically, chiller equipment is rated by its compliance to the given standard at the time of purchase. Over time, the standard tends to change. This results in equipment that was thought to be efficient relative to an older standard, but is now inefficient relative to the new standard. With this in mind, three efficiency ratings were defined and used to classify the chiller market shares into low-, medium-, and high-efficiency categories relative to the period the NRNC chiller data were collected. Chapter 4 provides additional details on how the ranges were established.

Exhibit 3-15 shows the market shares of air- and water-cooled chillers in each of the three efficiency classes for the 1994 through 1998 period.

Exhibit 3-15. Market Shares for Chiller Technologies (1994–1998)

1999 Non-Residential New Construction Baseline Study

Market Share for Chiller Technologies (1994 - 1998)

Chiller Type	Chiller Capacity	Efficiency Class	Efficiency Range kW/Ton	Market Share	Sample Size	Standard Error
Air Cooled						
	Less than 150 tons	High	Less than 1.05	2.4%	3	1.9%
	Less than 150 tons	Medium	1.05 through 1.10	1.7%	3	1.1%
	Less than 150 tons	Low	Greater than 1.10	95.8%	34	2.3%
			Total:	**99.9%**	**40**	
	150 through 299 tons	High	Less than 1.05	50.0%	2	23.0%
	150 through 299 tons	Medium	1.05 through 1.10	4.3%	1	4.8%
	150 through 299 tons	Low	Greater than 1.10	45.7%	5	22.3%
			Total:	**100.0%**	**8**	
Water Cooled						
	Less than 150 tons	High	Less than 0.75	15.2%	4	8.2%
	Less than 150 tons	Medium	0.75 through 0.85	25.0%	4	16.4%
	Less than 150 tons	Low	Greater than 0.85	59.8%	17	16.0%
			Total:	**100.0%**	**25**	
	150 through 299 tons	High	Less than 0.59	14.8%	7	9.0%
	150 through 299 tons	Medium	0.59 through 0.75	26.5%	11	13.4%
	150 through 299 tons	Low	Greater than 0.75	58.7%	10	16.4%
			Total:	**100.0%**	**28**	
	Greater than or equal to 300 tons	High	Less than 0.56	7.6%	12	3.0%
	Greater than or equal to 300 tons	Medium	0.56 through 0.65	44.3%	23	12.0%
	Greater than or equal to 300 tons	Low	Greater than 0.65	48.1%	20	12.2%
			Total:	**100.0%**	**55**	

Aspen's analysis of data from Non-Residential New Construction Baseline Study by RLW Analytics, Inc. for SCE, 1999

Air-Cooled Chillers

The performance standard in California for air-cooled chillers is and has been 1.13 kW/ton (Title 24). Models with an efficiency range of more than 1.13 kW/ton do not meet the Title 24 performance standard. Chillers with an efficiency range from 1.10 to 1.13 kW/ton nearly use the maximum power allowed and were deemed to be "low efficiency." Chillers in the 1.05 kW/ton to 1.10 kW/ton range were fairly efficient relative to the market and were deemed to be "medium efficiency." And, chillers in the 1.00 kW/ton to 1.05 kW/ton range were very efficient relative to the market and were classified as "high efficiency." Manufacturers' data indicated that a broad distribution of performance is available in the market, with power consumption as low as 1.00 kW/ton at most capacity values. However, no chillers were observed in the less than 1.00 kW/ton range. It appeared that models were clustered in the 1.05 to 1.10 range, with relatively few in the 1.00 to 1.05 range.

Based on these definitions, the market shares for efficient air-cooled chillers from 1994 through 1998 were:

- Less than 150 tons:
    - 96 percent were low efficiency
- 150 tons through 299 tons:
    - 46 percent were low efficiency
    - 4 percent were medium efficiency
    - 50 percent were high efficiency

Water-Cooled Chillers

For chillers with water-cooled condensers, the situation is more complex. The minimum (code) standard is capacity-based (lower power consumption is required for larger units) and the code has recently been updated. For example, the kW/ton standard prior to October 2001 for all water-cooled chiller types was:

- 0.676 for units greater than 300 tons
- 0.837 for units between 150 and 300 tons
- 0.925 for units less than 150 tons

After October 2001, standards were not only based on chiller size but also varied by chiller type. Based on the established criteria shown in Exhibit 3-15:

- Less than 150 tons (n=25):
    - 60 percent were low efficiency
    - 25 percent were medium efficiency
    - 15 percent were high efficiency
- 150 through 299 tons (n=28):
    - About 60 percent were low efficiency
    - 27 percent were medium efficiency
    - 15 percent were high efficiency
- Greater than or equal to 300 tons (n=55):
    - 48 percent were low efficiency
    - 44 percent were medium efficiency
    - 8 percent were high efficiency

For small and mid-sized chiller units, the trend seems to show that designers are selecting minimum-compliant units. For units that are greater than or equal to 300 tons, designers appear to be migrating from the low-efficiency to the medium-efficiency range, with medium-efficiency market share at 44 percent. This can be compared to the 26 percent medium efficiency units that are 150 through 299 tons and the 25 percent medium efficiency units that are less than 150 tons. Counter to this, the high-efficiency class has its lowest market share in greater than or equal to 300 tons at 7.6 percent. It would be expected that the largest units have a higher proportion of high-efficiency choices, given the substantial cost of running the very large units.

3.2.2.2 Chiller Data from Primary Research With Upstream Market Actors

Market Pathways

Chiller contractors and chiller manufacturers were asked to provide estimates of chiller unit sales for space cooling and process cooling (Exhibit 3-16), and estimates of chiller unit sales for space cooling in the new construction and the renovation/retrofit markets (Exhibit 3-17). Responses from the two segments show close agreement on the first question, but disparity on the second.

Exhibit 3-16. Responses of Chiller Contractors and Chiller Manufacturers to: "Please estimate the percentages of chiller units you sell for space-cooling and process-cooling applications"

Market Actor Segment	Space Cooling	Process Cooling
Chiller Contractors* [n = 16]	70.3%	29.4%
Standard Error	(15.1%)	(15.1%)
Chiller Manufacturers [n = 4]	73.8%	26.3%
Standard Error	(7.5%)	(7.5%)

* 0.3% also reported "Other"

Exhibit 3-17. Responses of Chiller Contractors and Chiller Manufacturers to: "Please estimate the percentages of chiller units you sell for space cooling in the new construction, renovation/retrofit, and expansion of existing facilities markets"

Market Actor Segment	New Construction	Renovation/ Retrofit	Expansion of Existing Facilities
Chiller Contractors [n = 19]	22.8%	62.0%	6.0%
Standard Error	(9.8%)	(13.5%)	(5.3%)
Chiller Manufacturers [n = 4]	42.5%	37.5%	20.0%
Standard Error	(16.5%)	(11.1%)	(7.1%)

Chiller contactors and chiller manufacturers were also asked to provide estimates of chiller sale revenues from various types of customers (Exhibit 3-18).

Exhibit 3-18. Responses of Chiller Contractors and Chiller Manufacturers to: "Please

estimate the percentages of revenue you receive from chiller sales to various types of customers"

Type of Customer	Contractors [n = 20]	Manufacturers [n = 3]
Wholesalers and Distributors	N/A	23.8%
Standard Error	(N/A)	(23.8%)
Builders and Developers	9.1%	8.3%
Standard Error	(5.2%)	(4.4%)
Mechanical and Gen. Contractors	18.2%	63.3%
Standard Error	(7.1%)	(14.5%)
Facility Owners and Managers	72.3%	13.3%
Standard Error	(8.8%)	(8.8%)
ESCOs	0.0%	6.7%
Standard Error	(0.0%)	(3.3%)
Other	0.3%	5.0%
Standard Error	(0.3%)	(2.9%)

Exhibit 3-19 summarizes the responses of chiller contractors when asked to provide estimates of the distribution of the dollar value of chiller products they buy from various sources.

Exhibit 3-19. Responses of Chiller Contractors (n=20) to: "Please estimate the percentages of the dollar value of chiller products you buy from various sources"

Source of Products	Product Value	Std. Error
National Manufacturers	56.3%	16.2%
Chiller Wholesalers and Distributors	43.7%	16.2%
Other	0.0%	0.0%

Customer Preferences, Decision Factors, and Barriers

One potential barrier to greater penetration of more energy-efficient chillers is that it may take longer to obtain than a standard-efficiency unit. Exhibit 3-20 shows the responses of chiller contractors and chiller manufacturers when asked to provide estimates of: 1) normal delivery times for "standard" chillers in two size ranges; and 2) what additional time would be needed if the chillers had options that improved their efficiency ratings.

Exhibit 3-20. Responses of Chiller Contractors and Chiller Manufacturers to: "Please estimate the delivery schedules (weeks) for 'standard' chillers in two size ranges. What additional time would be needed if the chillers had options that improved their efficiency ratings?"

Chiller Description	Contractors [n = 20]	Manufacturers [n = 3]
"Standard" Chillers, 200 to 500 tons	6.5	9.3
Standard Error	(1.4)	(0.9)
"Standard" Chillers, 500 tons and Larger	11.7	9.8
Standard Error	(0.4)	(1.3)
Additional time w/ Energy-Efficient Options	0.1	0.4
Standard Error	(0.1)	(0.4)

3.2.3 Windows

3.2.3.1 Window Data from Secondary Sources

The NRNC study provided an opportunity to estimate window market shares in the same manner as chillers and lighting. Exhibit 3-21 shows the market share for different window technologies, as developed from NRNC data.

In summary, the shares and trends are:

- From 1994 through 1998, single-pane windows held the market lead, with:
  - 78 percent market share in 1994
  - 72 percent market share in 1996
  - 79 percent market share in 1998
- The two-pane product, though considerably more efficient, did not grow its share of the new construction market substantially with:
  - 18 percent market share in 1994
  - 27 percent market share in 1996
  - 21 percent market share in 1998

While the double-pane product only had a 17 percent to 26 percent share through the late 1990s, this picture has changed dramatically with the 2001 adjustment to the Title 24 code. As shown later in Exhibit 3-27, the upstream market actor surveys indicated that the share of two-pane windows is now substantially higher.

Exhibit 3-21. Market Share Estimates for Windows

1999 Non-Residential New Construction Baseline Study

Estimated Market Share for Windows Technologies in Non-Residential New Construction

Utility Selected: PG&E/SCE/SDGE

Building	Technology	1994	1995	1996	1998
All Buildings					
1 Pane Clear Glass		30.40%	1.37%	27.06%	5.11%
	Standard Error:	(7.52%)	(0.77%)	(4.57%)	(1.23%)
1 Pane Reflective Glass		4.13%	18.58%	4.21%	31.04%
	Standard Error:	(2.05%)	(16.38%)	(1.30%)	(7.56%)
1 Pane Tinted Glass		43.75%	67.36%	41.34%	43.14%
	Standard Error:	(7.95%)	(19.86%)	(5.86%)	(7.62%)
2 Pane Clear Glass		2.29%	1.43%	6.26%	3.32%
	Standard Error:	(0.64%)	(1.23%)	(1.57%)	(1.25%)
2 Pane Reflective Glass		0.15%	0.00%	2.52%	0.04%
	Standard Error:	(0.15%)	(0.00%)	(1.26%)	(0.04%)
2 Pane Tinted Glass		15.65%	11.26%	18.15%	17.32%
	Standard Error:	(3.56%)	(10.50%)	(3.17%)	(5.03%)
3 Pane Clear Glass		3.63%	0.00%	0.00%	0.02%
	Standard Error:	(1.70%)	(0.00%)	(0.00%)	(0.01%)

Note: 1995 results should be used with caution as the sample was all SDG&E and there were only 30 observations.

3.2.3.2 Window Data from Primary Research With Upstream Market Actors

One upstream market actor segment (window suppliers) was surveyed for windows technologies. It should be noted that some of these suppliers also install, repair, or manufacture windows. In the course of conducting the survey interviews, Aspen found that a large number of window suppliers in the sample frame serve only or mostly the residential sector. There is no *a priori* way to exclude these suppliers, so an initial screening question was introduced to eliminate them from the sample as they were contacted.

Market Pathways and Roles of Key Decision-Makers

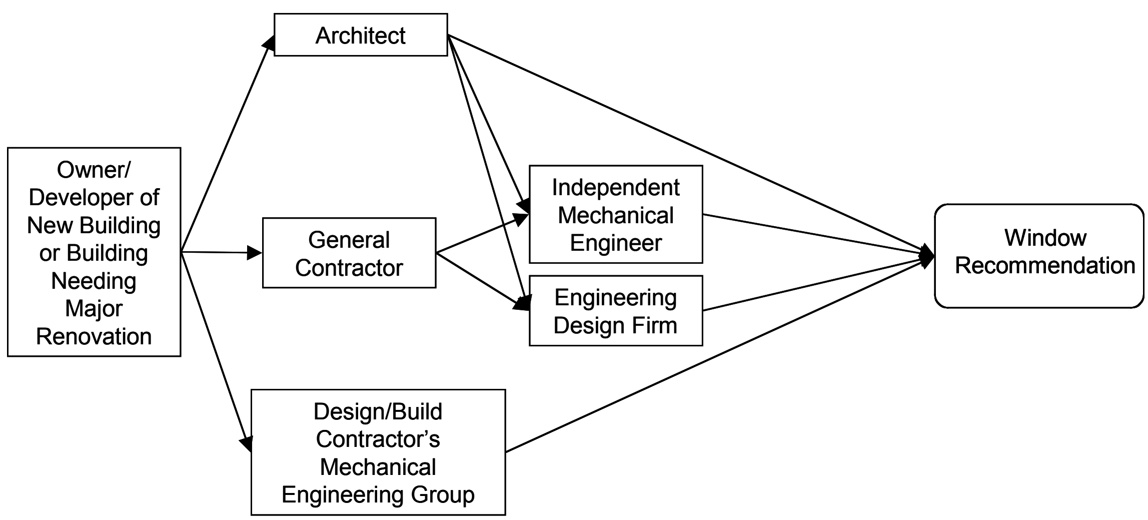
Since the Efficiency Market Share Needs Assessment and Feasibility Scoping Study was conducted, the nonresidential windows market has evolved. Some of the differences are:

- The role of the window specifier (e.g., architect, engineering design firm, design/build contractor) was not discussed in the scoping study. Aspen found that the specifier plays a major role in deciding the efficiency of window systems installed in nonresidential buildings. Windows suppliers bid and sell to these specifications.

- Window-wall systems and store-front window systems continue to require that the window glass be installed on site, as noted in the earlier study. However, many nonresidential buildings now use smaller, pre-fabricated windows, which are constructed or purchased by the window supplier and shipped to the site ready for installation.
- A window thermal-rating system has been created by the National Fenestration Rating Council to rate windows on their thermal performance.
- Use of window film has significantly decreased.
- Window sash (or frame) material has always been a decision factor in window selection because the color, width, and profile of this component must be consistent with other windows and the architectural characteristics of the building. It has also become an energy-efficiency feature in many installations because of the alternative U-values available with different sash materials and "thermal-break" designs.
- There continues to be few differences between the market infrastructure for new construction and retrofit windows.

Exhibit 3-22 depicts the variety in the flow of authority for the decision to choose the type of window for new construction or renovation windows.

Exhibit 3-22. Flow of Authority for Recommending Windows for Nonresidential Buildings



Minimal difference exists between the new construction market and the renovation/retrofit market in terms of who makes the recommendation for window design and equipment. There also is little difference between the new construction market and renovation/retrofit market in terms of suppliers and the flow of windows materials. Three types of supplier exist:

- Fabricators who make and install window-wall, curtain-wall, and storefront systems
- Fabricators who buy window glass to pre-fabricate windows with sashes to order
- Vendors who buy and sell pre-fabricated windows with sashes

All three serve both markets. Exhibit 3-23 shows the variety in the flow of materials for the windows market.

Exhibit 3-23. Market Flow of Windows Products for Nonresidential Buildings

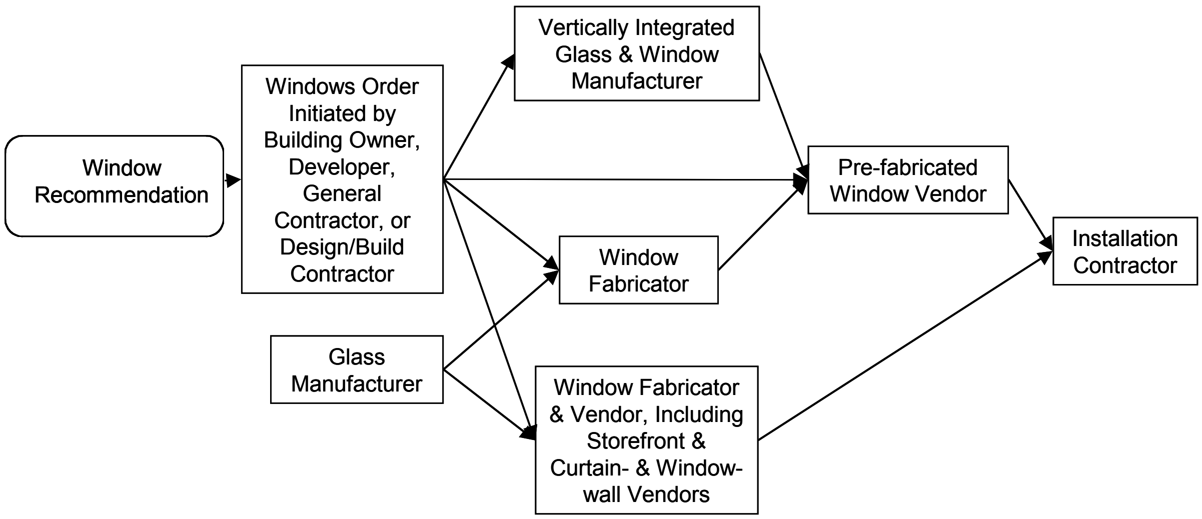


Exhibit 3-24 shows the responses of window suppliers when asked to provide estimates of the distribution of the dollar value of window products they buy from various sources.

Exhibit 3-24. Responses of Window Suppliers (n=23) to: "Please estimate the percentages of the dollar value of window products you buy from various sources"

Source of Products	Product Value	Std. Error
Flat Glass Manufacturers	33.3%	9.8%
Window Glass Wholesalers and Distributors	35.7%	9.8%
Prefabricated Window Manufacturers	28.6%	9.2%
Window Tint Film Manufacturers	1.6%	1.6%
Other	0.9%	0.9%

Window film continues to be retrofitted to existing windows, however, it is rarely seen in new or replacement windows.

As can be seen in Exhibit 3-25, the customer segment that provides window suppliers with their largest revenues is general contractors, with builders and developers second.

Exhibit 3-25. Responses of Window Suppliers (n=23) to: "Please estimate the percentages of revenue you receive from sales to various types of customers"

Type of Customer	Revenue Share	Std. Error
General Contractors	46.9%	8.7%
Builders and Developers	27.0%	7.9%
Facility Owners and Managers	8.3%	3.2%
Property Management Firms	1.7%	1.0%
Architects and Engineers	7.2%	2.9%
Other	8.7%	6.0%

Exhibit 3-26 shows that the new construction market provides window suppliers with nearly twice the revenues as the renovation/retrofit market.

Exhibit 3-26. Responses of Window Suppliers (n=23) to: "Please estimate the percentages of your sales revenue from the new construction and renovation/retrofit markets"

Market	Revenue Share	Std. Error
New Construction	65.0%	7.2%
Renovation/Retrofit	35.0%	7.2%

When window suppliers were asked to name the brands of windows they handled, the five most frequent responses were:
- Milgard
- Fleetwood
- International
- Mercer
- All-Weather

Market Shares of Energy-Efficient Features and Equipment

Window suppliers were asked to provide the approximate percentages of windows they sell that have various energy-efficient features. Their responses are summarized in Exhibit 3-27.

Exhibit 3-27. Responses of Window Suppliers (n=24) to: "Please estimate approximate percentages of windows you sell that have the following energy-efficiency features"

Energy-Efficiency Feature	Share	Std. Error
Double Pane	71.0%	7.0%
Triple Pane	1.3%	1.1%
Low-Emissivity Coating	47.5%	7.4%
Tinting	18.0%	5.7%
Reflective Coating	4.7%	2.0%
Other (e.g., laminated)	0.8%	0.8%

This exhibit provides further evidence that the nonresidential windows market has evolved since the scoping study was performed. Some of the differences are:

- Following the revision of Title 24 in August 2001, double-pane glass has become the standard for the most part. About 70 percent of windows sold for replacement and new construction use double-pane glass. This market-share value is approximately triple the market shares for this efficiency feature—18 percent to 26 percent—reported for 1994 through 1998 in the NRNC study, as analyzed and reported in the Public Database (see Exhibit 3-21). That it is a code requirement, but is not 100 percent implemented is explained in Exhibit 3-25, which shows that about 74 percent of the suppliers' sales share is new construction (i.e., sales to general contractors, builders, and developers) and subject to the code, and about 20 percent to 25 percent is to maintenance, property management, and other replacement markets. This accounts for the residual share of single-pane sales.
- About 48 percent of new windows are now being ordered with low-emissivity coatings. To the extent window film is used, it is used on existing windows and is applied by vendors other than window suppliers.

Prices

Window suppliers were asked to provide the approximate price for one "no frills" window in a lot of 25, all single-pane measuring 4-feet by 5-feet, with fixed glazing having a light-gray tint. The mean price quoted for the "no frills" low-efficiency window was $384. Window suppliers were then asked to quote the approximate percentages price adder for each of the various energy-efficient features. The means of their quotations of percentage adders for the various energy-efficient features are presented in Exhibit 3-28.

Exhibit 3-28. Mean of Percentage Price Adders Quoted by Window Suppliers (n=24) for Various Energy-Efficiency Features Added to a "No Frills" 4'x5' Single-Pane Window with a Mean Price of $384

Energy-Efficiency Feature	Price Adder	Std. Error
Double Pane	31.5%	6.4%
Triple Pane*	6.8%	4.9%
Low Emissivity Coating	9.4%	3.1%
Tinting	8.2%	3.8%
Reflective Coating	7.6%	4.1%
Other (e.g., Laminated)	1.1%	1.1%

* Price understood to be relative to a double-pane window.

Data obtained in this study is consistent with the prices shown in DEER, as reported in the Public Database:

- Mean price of no-frills, single-pane, 4' by 5' window (tracking study survey) $384.00
- Implied price per square foot (4' by 5' = 20 square feet) $19.20
- Price from DEER per square foot for "new window, double (pane), aluminum frame, argon gas" $25.00
- Ratio of DEER price (per square foot) to Aspen's "no-frills" price ($25.00/19.20) 130%
- Mean of reported price premiums for double-pane window from tracking study survey 132%

The consistency between these estimates is noteworthy, and lends credence to the estimates developed in both studies.

Customer Preferences, Decision Factors, and Barriers

Window suppliers were asked if customers buying windows for new construction projects seem to have different preferences or objectives than customers buying for renovation/retrofit projects. Exhibit 3-29 summarizes the responses.

Exhibit 3-29. Responses of Window Suppliers (n=23) to: "Do customers for new construction projects seem to have different preferences or objectives than customers for renovation/retrofit projects?"

Response	Estimate	Std. Error
Yes	21.7%	8.8%
No	43.5%	10.6%
No Opinion	34.8%	10.2%

The following key differences were reported between the new construction and renovation/retrofit subsectors:

- New construction is more price conscious, largely because there are typically multiple general contractors bidding and each obtains quotes from multiple suppliers. For renovation/retrofit, the customer-owner will often check on the supplier's reputation.
- Renovation/retrofit is often more expensive because a custom design is needed to fit windows to existing wall openings or it may be necessary to match existing architectural features (e.g., sash design and color).
- New construction is more interested in energy efficiency.
- Renovation/retrofit may have a greater concern about sound transmission.
- Renovation/retrofit typically has two concerns: (1) delivery schedule; and (2) matching other windows and existing architectural features.

Exhibit 3-30 shows the responses of window suppliers when asked to provide estimates of: 1) normal delivery times for "standard" windows; and 2) what additional time would be needed if the windows had special energy-efficiency features.

Exhibit 3-30. Responses of Window Suppliers to: "Please estimate the delivery schedules (weeks) for 'standard' windows. What additional time would be needed if the windows had special energy-efficiency features?"

Times	n	Weeks	Std. Error
Delivery Period for "Standard" Design	19	5.1	0.7
Additional Time with Energy-Efficient Features	17	0.1	0.1

Other Market-Characterization Data

The following comments and suggestions concerning ways to get more efficient windows into the nonresidential market were made by some respondents at the conclusion of the interview:

- More advertising on energy-efficient windows is needed to make the public aware that energy-efficient windows are available and can save money.
- There needs to be more education for customers, specifiers, and dealers concerning the operating-cost savings that result from reducing heat gains by use of tinting and reflective coatings.
- Programs should advertise that films for glass promote comfort and saves money.
- Rebate programs should be more applicant-friendly. For example, the application form for PG&E's residential windows program is too complicated and many potential participants do not want to spend the time to complete it.
- Rebates are working well in the residential sector. Maybe there should be more promotion of rebates for highly efficient nonresidential windows.
- Residential rebates are a huge success. Rebates for nonresidential windows would result in greater penetration and lower space-cooling costs.
- A number of large buildings waste a great deal of energy because they have single-pane windows that are 10 to 30 years old. Incentives would give a needed stimulus to get these windows upgraded. The programs should target architects, since they prepare the specifications.
- Most nonresidential buildings have a great deal of square feet of single-pane windows. A lot of energy could be saved by going to more-efficient windows.

- Provide rebates for low-e windows. Require installers to be bonded and insured.
- Provide and advertise the availability of cash incentives.
- Advertise.
- The default performance-rating values specified in the Title 24 regulations are well accepted. It would be prohibitively expensive to test and rate each custom window design.
- Buyers want double-pane windows. CEC and utility programs should ensure the double-glass “system” is reliable and warranted to protect buyers from “fogged glass” that result when the seal fails.
- Single-pane is by far the most common window type in existing facilities, driven by cost considerations and concern about seal failure and resulting condensation on the inner surfaces.

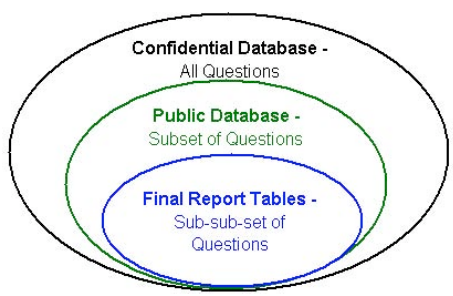
3.3 Primarily Industrial Applications

Aspen collected industrial energy-efficiency market share data by surveying 560 industrial facilities. The questions and responses will help CEC and utility program planners design targeted and cost-effective energy-efficiency programs by highlighting technologies and market segments that appear to hold significant savings potential.

Because this is a tracking study, if the survey is repeated in future years, the results will gradually reveal trends in energy-efficiency practices and identify market segments that lag their peers in taking advantage of good investments and those technologies for which saturations have plateaued at low levels in California.

The Confidential Database created for this study contains the raw data collected with Aspen’s Industry Energy End-User Survey questionnaires and sample weights. The Public Database has a user-friendly front-end and all data that could identify individual facilities are hidden. Its output is based on responses made to a subset of the survey questions. Results include:

- Weighted responses to selected questions deemed to be of particular significance
- Selected cross-tabulations on topics of interest
- Results based on comparison of survey data with external data
- Results based on survey data used in engineering calculations



This section presents key findings extracted from the Public Database. The exhibits show aggregated results across utility service territories. SIC 20, 35, and 36 results (surveyed in 2001–2002) are presented individually. The tables aggregate results for the remaining SICs surveyed in 2002–2003. Interested parties may perform additional data drilling—segmentation by SIC and/or service territory for example—from the Public Database.

In some cases, comparing the results of the two surveys has merit. However, more often, it is inappropriate, especially if attempting to project the results as a time-based trend. The populations were not the same (different SICs) in the two studies, and the transient effects of the

"California energy crisis" may appear more in one phase than the other, depending on the question asked. Generally, it is recommended that the results be considered together as two perspectives on different but overlapping fragments of a picture rather than as the first two points of a time-based trend analysis.

This section references ranges of results. As a general rule, the upper and lower numbers in those ranges refer to the summary estimates of the two phases and not the SIC-specific results. Standard errors appear in database tables and printouts, but are not displayed when ranges of results are provided in this report.

The 11 subsections in this section of the report are arranged by technology in the following order:

1. Motors
2. Process Fluid Pumping
3. Gas Process Heating
4. Refrigeration
5. Compressed Air
6. Water Recovery and Reuse
7. Electronic Control of Process Equipment
8. Power Generation
9. Maintenance Practices
10. General Information
11. Market Channels

While the results focus primarily on reported end-user statistics, Aspen also interviewed 28 vendors and industry experts for eight of the technologies. These open-ended interviews helped refine the tracking study's industrial end-user questionnaire and develop pre-survey estimates of market share. The interviews also provided insightful—though non-statistical—primary data. Selected findings from this investigation are included in this section. As is noted, suppliers sometimes overestimated their customers' energy awareness (see motors), sometimes underestimated it (see electronic process controls), and sometimes predicted it accurately (see auto-lubrication).

3.3.1 Motors

One of the primary objectives of the tracking study was to determine the market share of NEMA-defined "premium-efficiency" motors for purchases made in the last three years. To accomplish this, Aspen sampled up to 10 motors at each site and over-sampled large motors. The survey instrument was designed to collect data on each of three different paths by which a motor might get onto the plant floor. These include: motors that arrive bundled with new purchased packaged equipment; traditional standard replacement motors that are pulled from a storeroom or just-in-time cooperating supplier; and special-order replacement motors that are ordered and installed. Exhibit 3-31 summarizes the results of the survey, which included nameplate data collection on a stratified random sample of more than 2,200 motors sized 1 horsepower and above.

Exhibit 3-31. Premium-Efficiency Motor Market Share

Questions and Responses	2001–2002								2002–2003	
	SIC 20		SIC 35		SIC 36		SICs 20, 35, 36		SICs 21-34, 37-39	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
Percentage of HP of motors bought in last 3 years meeting or exceeding NEMA Premium-efficiency Standards										
1 - 49 hp	22.8%	10.9%	35.7%	7.9%	6.6%	2.2%	**15.8%**	4.1%	**8.5%**	2.7%
50 - 200 hp	18.7%	6.1%	W	W	19.0%	5.0%	**17.5%**	3.4%	**20.2%**	5.6%
Total 1 - 200 hp	21.3%	7.1%	23.4%	9.1%	10.4%	2.5%	**19.0%**	4.2%	**12.6%**	3.1%

W = Withheld

In 1997, the U.S. DOE commissioned a nationwide study of energy-efficiency market practices that covered some of the same issues Aspen investigated in California.[3] The DOE survey reported that the saturation of premium-efficiency motors was 9.1 percent. While not directly comparable, Aspen's survey found new motor market shares to be 19 percent (Phase 1 industries) and 12.6 percent (Phase 2 industries), suggesting California has a higher saturation of premium-efficiency motors.

Between 36 percent and 58 percent of the total new motor horsepower brought into California plants over the last three years came in to the plant "on skids" as part of packaged equipment, representing a major entry path for motors (Exhibit 3-32). It also is evidence that premium-efficiency motor programs will never deliver a saturated market if they focus solely on individual motor purchases. Exhibit 3-32 illustrates this result, as well as proportions for the other two types of purchases noted previously. Proportions are weighted in terms of motor horsepower.

Exhibit 3-32. Source of New Motors

Questions and Responses	2001–2002								2002–2003	
	SIC 20		SIC 35		SIC 36		SICs 20, 35, 36		SICs 21-34, 37-39	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
Please estimate the source of motors bought for your facility in the last 3 years:										
As part of packaged equipment	44.9%	10.2%	64.5%	9.2%	56.3%	11.2%	**58.3%**	6.2%	**36.1%**	8.3%
Inventory replacement motor such as stocked in an on-site store room	44.1%	10.6%	17.3%	7.8%	35.0%	10.9%	**27.4%**	5.6%	**33.0%**	9.3%
Special-ordered motor other than out-of-stock in hand	11.0%	4.7%	18.2%	7.9%	8.6%	3.4%	**14.3%**	4.4%	**30.8%**	12.4%

Premium-efficiency motor purchasing policy questions were posed separately for each of the three paths. This allowed analysts to determine if any particular path was more or less effective at delivering premium motors to plants. As shown in Exhibit 3-33, between 6.6 percent and 24 percent of customers routinely request premium-efficiency motors when buying new packaged equipment with motors (Path 1). Of those firms that stock back up motors, between 1 percent and 29 percent have a policy to routinely stock premium-efficiency motors (Path 2).

Motor procurement procedures at industrial facilities with SICs 20, 35, and 36 are more likely to include a clause specifying that premium-efficiency motors be purchased than at other facilities. As shown in Exhibit 3-33, 24 percent of customers at SICs 20, 35, and 36 request that premium-efficiency motor upgrades be included in packaged equipment procurements, as opposed to 7 percent at SICs 21-34 and 37-39. Similarly, 29 percent compared to 1 percent routinely purchase premium-efficiency motors for stock motor replacements.

Exhibit 3-33. Premium-Efficiency Motor Purchasing Policies

Questions and Responses	2001–2002								2002–2003	
	SIC 20		SIC 35		SIC 36		SICs 20, 35, 36		SICs 21-34, 37-39	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
Path 1: Does your purchasing department have a standard clause or routinely follow a procedure to specify that 'premium-efficiency' motors must be used when **packaged equipment** is purchased?										
Yes	42.2%	10.8%	17.3%	8.9%	23.1%	10.1%	**24.2%**	5.9%	**6.6%**	3.0%
No	56.3%	10.8%	82.4%	8.9%	69.9%	10.7%	**73.8%**	6.0%	**89.3%**	3.6%
Under Certain Conditions	1.3%	0.9%	0.3%	0.3%	4.3%	2.8%	**1.4%**	0.7%	**1.7%**	1.2%
Not Sure	0.1%	0.1%	0.0%	0.0%	2.7%	2.7%	**0.6%**	0.6%	**2.4%**	1.6%
Missing	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**	0.0%	**0.0%**	0.0%
Path 2: When buying **inventory replacement motors** such as those stocked in an on-site store room, do you have a policy about the efficiency level to buy?										
Specify premium-efficiency motors (2001-02 survey only)	39.2%	10.9%	25.3%	10.7%	27.1%	10.1%	**28.8%**	6.8%		
Specify NEMA premium-efficiency motors (2002-03 survey only)									**1.1%**	0.4%
Buy motors billed as 'energy-efficient', no particular attention to if they are NEMA premium-efficiency motors (2002-03 survey only)									**4.5%**	2.5%
Buy "regular" efficiency*	5.3%	1.4%	0.5%	0.3%	17.5%	9.4%	**5.4%**	2.1%	**3.1%**	1.6%
Consider trade-off between efficiency and price									**2.3%**	2.1%
No particular policy regarding energy use	37.1%	10.9%	49.8%	11.2%	40.2%	11.0%	**44.8%**	7.1%	**71.7%**	5.5%
Plant does not stock any back-up motors	18.4%	9.4%	24.4%	5.7%	12.0%	5.0%	**20.3%**	4.0%	**17.1%**	4.7%
Don't know									**0.3%**	0.2%
Missing	0.0%	0.0%	0.0%	0.0%	3.2%	3.2%	**0.7%**	0.7%	**0.0%**	0.0%

* This includes motors labeled "Standard Efficiency" or "Energy-Efficient."

These policy differences became apparent through motor sample analysis. As was shown in Exhibit 3-31, about 19 percent of 1 horsepower to 200 horsepower motors in SICs 20, 35, and 36 were premium-efficiency, compared with about 13 percent in other SICs. Closer inspection of the inventory data shows that most of the difference is due to differences in the 1-49 horsepower range. In the 50-200 horsepower range, SIC groups had 17 percent to 20 percent premium-efficiency motors. The average total customer annual energy use in the two groups is roughly the same.

There may be a link between products manufactured at a site and motor procurement policy, but the stronger link may be between customers that buy more smaller motors and customers that do not have premium motor policies. Customers that buy smaller motors may believe that the purchase of smaller motors does not warrant the establishment of a premium-motor policy.

Buyers rarely consider the cost effectiveness of the incremental investment in a single motor purchase. Less than 3 percent of the time do buyers weigh the extra cost of an individual premium-efficiency motor and calculate the savings gained by upgrading to that motor (question asked in Phase 2 only), as shown in Exhibit 3-33. Because of this, policies and programs, such as Web calculators offered to help facilities managers evaluate cost effectiveness, offer limited value. At best, staff may use them to help develop policies, but will most likely not use them as individual purchase opportunities arise. Programs should focus at the policy level of motor decision-making and not on individual purchase decisions.

When designing the questionnaire, Aspen interviewed suppliers for feedback and was told that "premium-efficiency" would be a term with which users are familiar in regard to motors. The questionnaire was designed accordingly in Phase 1.[4] However, field staff reported having definitional difficulties with respondents. For Phase 2, a question to test suppliers' term knowledge was added. The additional question also enabled surveyors to explain the term "premium" to those who were not familiar with it.

Aspen found awareness to be lower than the suppliers expected. While the majority of respondents generally were aware that motor efficiency was a variable and that "high" efficiency motors could be specified, Exhibit 3-34 illustrates that awareness of the specific and official meaning of "premium" was described by slightly more than 16 percent of the interviewees.

Exhibit 3-34. Understanding of Term "Premium-Efficiency Motor" Reported in the 2002–2003 Survey

Questions and Responses	SICs 21-34, 37-39	
	Estimate	Std. Error
Some of my questions will be about 'premium-efficiency motors,' a term that was used loosely by motor vendors, at least in the past. What does this term mean to you?		
Definition included "meeting or surpassing NEMA standards" or similar	**16.3%**	4.2%
Other	**83.7%**	4.2%

New premium-efficiency motors compete with new non-premium-efficiency motors for sales and with the option of rewinding motors. When the mode of motor failure allows for it, the cost to rewind a large motor is less than buying a new one. In some of those situations, the total lifetime electricity cost savings realized by buying a new premium-efficiency motor would never recover the first-cost to buy a new motor instead of rewinding. In other cases, however, it is cost effective to invest in a new premium-efficiency (or new non-premium-efficiency) motor rather than rewinding an old one, even when the new purchase costs more initially.

Exhibit 3-35 lists the reasons facilities staff choose to rewind. First-cost savings is the top reason cited for rewinding. Fast turnaround time is second with about 40 percent of the respondents citing it as a reason to rewind motors. Since premium-efficiency motors are or are perceived to be less available across all size classes than standard motors and may have longer delivery times on average, this factor becomes a double barrier to new premium-efficiency motor sales. As plants follow the trend of stocking fewer motors and other parts on site, the barrier will become a bigger issue.

Exhibit 3-35. Why Motors Are Rewound

Questions and Responses	2001–2002								2002–2003	
	SIC 20		SIC 35		SIC 36		SICs 20, 35, 36		SICs 21-34, 37-39	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
When you choose to rewind, what are the main reasons you do so? Check all that apply.										
Lower first cost	89.4%	3.2%	42.7%	16.9%	76.6%	6.4%	**55.2%**	11.9%	**69.0%**	8.7%
Faster turnaround time	63.1%	12.8%	32.0%	14.3%	44.5%	7.5%	**39.2%**	10.4%	**44.3%**	9.5%
To keep older motors, which are built better than new ones	6.9%	2.9%	35.0%	16.9%	29.8%	7.3%	**29.2%**	11.9%	**2.9%**	1.0%
Rewinding does not require funds from the capital budget	4.6%	2.7%	0.0%	0.0%	2.3%	1.1%	**1.1%**	0.5%	**4.1%**	3.0%
We rewind pre-EP Act (1997) motors only, because they are cheaper to rewind	0.0%	0.0%	13.3%	12.8%	0.0%	0.0%	**9.4%**	9.0%	**6.5%**	3.6%
To adjust from nameplate voltage to actual plant voltage	0.9%	0.9%	0.2%	0.2%	0.0%	0.0%	**0.3%**	0.2%	**0.2%**	0.1%
Other	39.8%	3.6%	15.8%	12.9%	9.8%	6.2%	**19.7%**	9.1%	**18.2%**	7.0%

Some experts claim that a well-rewound motor can match or even exceed the efficiency of the original motor when sold. Given the economic facts of rewinding, the large numbers of customers that rewind, and the value they place on a fast turnaround time, it may be worth concentrating on improving the rewind practices, as well as promoting premium-efficiency motors. Exhibit 3-36 shows that there is substantial room for improvement on the purchasing side of the transaction in this regard. With the exception of 22 percent to 27 percent of customers requesting a repair report, only small proportions of customers (1 percent to 13 percent in 2001–2002; 1 percent to 15 percent in 2002–2003) requested the quality assurance features shown on Exhibit 3-36.

Exhibit 3-36. Motor Rewind Quality Assurance Features Required By Customers

Question and Responses	2001–2002								2002–2003	
	SIC 20		SIC 35		SIC 36		SICs 20, 35, 36		SICs 21-34, 37-39	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
When you have a motor rewound, do you require the rewind shop to provide any quality assurance features? What do you require (check all that apply)										
Delivery of oven chart recorder burnout temperature	2.9%	2.1%	1.5%	1.4%	3.4%	3.4%	**2.0%**	1.1%	**3.3%**	2.2%
Repair report	33.6%	15.7%	20.3%	12.9%	16.6%	4.7%	**22.4%**	9.6%	**26.7%**	7.4%
Winding resistance test results	8.1%	2.6%	15.0%	12.9%	10.1%	4.3%	**13.2%**	9.1%	**15.0%**	6.5%
Core lost test results	18.7%	15.4%	2.0%	1.5%	5.0%	3.5%	**5.5%**	3.1%	**6.7%**	5.4%
Identical materials replacement	2.1%	1.2%	2.9%	1.6%	1.6%	1.0%	**2.6%**	1.2%	**5.0%**	3.0%
Lap windings instead of concentric windows	0.0%	0.0%	1.4%	1.4%	3.4%	3.4%	**1.3%**	1.0%	**1.0%**	0.3%
Other	1.6%	1.1%	0.7%	0.5%	10.9%	6.4%	**2.0%**	0.8%	**7.9%**	3.9%

3.3.2 Process Fluid Pumping

Pump questions were asked only in Phase 2 and only if the site had at least 50 horsepower of pumps. Exhibit 3-37 tabulates the energy-related maintenance and upgrade activity for this technology. The scope of the question is limited in that the time period associated with "ever performed" was limited to the interviewee's experience at the facility. Replacing worn impellers or bearings, a routine maintenance activity, was by far the most common activity with 77 percent of the facilities having done so in the last three years. Activities that directly save energy, such as trimming impellers, replacing with higher efficiency pumps, and increasing pipe diameters, have lower but still substantial activity levels. Many of these types of upgrades improve system performance and save energy. This segment of the industrial market may be most responsive to programs and messages that stress the non-energy benefits in efficiency measures. Overall, the responses seem to reflect a relatively high level of energy-efficiency awareness and activity with pumps.

Exhibit 3-37. Pump Efficiency Upgrades Reported in the 2002–2003 Survey

Questions and Responses	SICs 21-34, 37-39	
	Upgrade ever performed	Upgraded in last 3 years
Trimmed pump impellers	**11.8%**	**5.2%**
Installed or modified pump control system	**23.7%**	**18.3%**
Redesigned pipe layout to reduce friction losses	**49.0%**	**42.9%**
Replaced with higher efficiency pumps	**41.8%**	**34.4%**
Increased piping diameter	**47.1%**	**38.6%**
Replaced worn impellers or bearings	**88.4%**	**77.0%**

3.3.3 Gas Process Heating

The Gas Process Heating section was added in Phase 2 at the suggestion of the stakeholders.[5] Aspen asked gas questions only if the site had at least 10,000 therms/year or $5,000/year of gas bills. Because it was added in Phase 2, the results do not include responses from SIC 20 (food processing), which would most likely be one of the largest gas users. The principal findings are provided in Exhibit 3-38.

Exhibit 3-38. Gas Process Heating Utilization Reported in the 2002–2003 Survey

Responses	SICs 21-34, 37-39	
	Estimate	Std. Error
Percent with >10,000 thm/yr or >$5,000/yr gas use	27.1%	2.5%
Estimated annual gas expenditure per site	$1,343,000	$631,000
Proportion citing use of:		
Gas Boiler	45.1%	4.8%
Gas Ovens	42.5%	4.9%
Gas Furnaces	28.2%	4.5%
Gas Dryers	16.8%	3.3%
Gas Kilns	11.7%	2.4%
Other	24.1%	4.2%

Twenty-seven percent of the facilities surveyed in Phase 2 were significant gas users.[6] Gas-using equipment was primarily boilers, followed by furnaces, ovens, dryers, kilns, and other items. The mean annual gas expenditure was in excess of $1,340,000 per site.

Respondents were asked about a variety of energy-efficiency options associated with gas boilers. The data are presented in Exhibit 3-39 as saturations, not market shares. Two sets of data are presented. The first pertains to measures present on boilers, irrespective of when the measure was purchased and whether they were part of the original boiler installation or were added later. The second set pertains to measures installed during the past three years.

Responses demonstrated what researchers judge to be high activity levels overall. Over 20 percent of the facilities had incorporated heat recovery in their boiler systems. The presence of electronic ignition at 31 percent is an example of a market that is approaching transformation, since not all boiler applications are appropriate for the technology. Even measures that are relatively less common, such as turbulators, were installed at 10 percent of the sites.

Participants also had an opportunity to report on retrofit-type changes made to the boilers. The most common were reducing the steam pressure and increasing boiler piping and jacket insulation.

Exhibit 3-39. Gas Boiler Energy-Efficiency Options Reported in the 2002–2003 Survey

Questions and Responses	SICs 21-34, 37-39	
	Estimate	Std. Error
Gas process heating energy-efficiency options present on boilers		
Stack heat recovery	22.2%	5.5%
Condensate heat recovery	20.9%	5.5%
Other heat recovery	7.5%	4.5%
Automated tuning (O_2 trim control)	13.8%	4.9%
Electronic ignition	31.1%	4.9%
Turbulators for firetube boilers	9.9%	4.8%
Gas process heating energy-efficiency options installed on boilers in the last three years		
Stack heat recovery	10.7%	4.8%
Condensate heat recovery	3.0%	1.7%
Other heat recovery	0.0%	0.0%
Automated tuning (O_2 trim control)	1.9%	1.0%
Electronic ignition	11.8%	4.9%
Turbulators for firetube boilers	0.7%	0.7%
Increased pipe and boiler jacket insulation	22.1%	1.3%
Reduced boiler blow-down cycle	3.6%	1.6%
Reduced steam pressure	37.6%	0.7%
Variable speed drives on larger forced-draft and induced-draft fans	2.4%	1.5%
Automatic flue damper	4.3%	2.1%
Smaller boiler for low-load conditions	0.7%	0.7%
Other	0.2%	0.2%

3.3.4 Refrigeration

Refrigeration questions were asked of sites with at least 20 horsepower of mechanical cooling for other than human comfort. It is the one technology section for which the two phases would be expected to differ markedly because food processors were included in Phase 1 only. Given food processors' higher proportion of costs for refrigeration and their higher absolute refrigeration energy costs relative to other manufacturers, it is no surprise that Exhibit 3-40 shows more energy-efficiency options installed in Phase 1 facilities. As might be expected, use of ammonia is more than an order of magnitude higher in SIC 20 plants than in others.

The floating-head results roughly correspond with the suppliers' predictions of low to moderate market share and their explanations as to why this would be so. According to suppliers, floating head below 70 degrees saturated condensing temperature is rarely done; however, head is usually allowed to float to some degree in all designs. Electronic expansion valves, which would allow some systems to float the head pressure down, have not been widely accepted by the industry. Apparently, these valves are problematic. Other design concepts, such as surge receiver and liquid pump amplification, are not in use or are problematic as well.[7]

Exhibit 3-40. Market Saturation Ratios for Selected Refrigeration Efficiency Options

Responses	2001–2002*		2002–2003	
	SIC 20		SICs 21-34, 37-39	
	Estimate	Std. Error	Estimate	Std. Error
Percentage of refrigeration horsepower with heat recovery	**8.8%**	4.8%	**1.5%**	0.4%
Percentage of refrigeration horsepower with floating head	**25.7%**	11.1%	**4.3%**	4.3%
Percentage of refrigeration horsepower that is ammonia based	**79.6%**	6.6%	**4.3%**	4.3%

* Refrigeration questions were not asked of SIC 35 and 36 respondents in Phase 1.

Exhibit 3-41 shows more recent activity installing VSDs for Phase 2 respondents, but the difference is not statistically significant.

Exhibit 3-41. Recent Installation of Variable Speed Controls for Process Cooling Towers

Questions and Responses	2001–2002		2002–2003	
	SIC 20		SICs 21-34, 37-39	
	Estimate	Std. Error	Estimate	Std. Error
Has your plant purchased variable speed controls for any of the refrigeration system cooling towers in the last five years?				
Yes	**6.4%**	2.3%	**5.9%**	2.7%
No	**92.0%**	2.7%	**94.1%**	2.7%
Don’t Know	**0.0%**	0.0%	**0.0%**	0.0%
Missing	**1.6%**	1.6%	**0.0%**	0.0%

According to the suppliers in 2001, screw compressors driven by variable-speed controls were an emerging technology not yet sold on the market. Oil and rotor sealing constraints associated with lowering the rotational speed of the compressor apparently have recently been overcome by new designs. These new compressors are just now coming to market.

3.3.5 Compressed Air

Compressed-air systems use a tremendous amount of energy nationwide and a substantial percentage of energy at individual sites—and the vast majority of industrial plants have them. These two factors make them one of the biggest targets for upgrading in the energy-efficiency community. However, it can be difficult to reduce their energy use because compressed-air systems have many different hardware, controls, and maintenance issues that individually do not seem to use much energy but collectively can waste a great deal. Typically, there is no “silver bullet” to saving energy in a compressed-air system, but the cumulative effect of small improvements sometimes is sufficient to take a 300-horsepower compressor off line.

In the survey, there were more questions about compressed air than any other single technology because of the disparate nature of the elements that effect energy use. Collective measurement of these indicators of energy-efficiency market share and efficient behavioral practices gives program designers and evaluators a sense of the level of energy-efficiency activity in the state.

Aspen collected data on compressed-air systems at a site only if the site had at least 50 horsepower of compressed-air systems. Aspen interviewed two vendors as part of the supplier interviews. Both vendors agreed that system-wide waste was the biggest source of inefficiency and that customers need to be educated on financial- and productivity-related reasons to invest in compressed-air system improvements. (Note: Aspen used these interviews to develop the survey. The responses are not meant to constitute a representative sample.) The interviewees provided indicators to judge the system operating efficiency that reflected most of the questionnaire's multiple-choice answers.

Compressor part-load controls represent a source of savings at many sites. For example, throttle-controlled air compressors are very inefficient at part load, using twice the power per cubic feet per minute (cfm) at 40 percent capacity as they do at 100 percent capacity. Still, throttling is the least expensive form of control for many types and sizes of compressors because it is reliable and convenient. It remains common in industry.

Exhibit 3-42 shows that other more efficient means of control than throttles, such as variable volume, VSDs, and cycling, constitute 33 percent to 40 percent of the market in terms of horsepower. It is expected that the majority of the throttle-controlled units are in the smaller horsepower systems. Even after accounting for this factor, it is likely that California could realize substantial savings potential by switching modulating compressors to other modes of control than throttling.

Variable speed drives are one of several much more efficient part-load control options. VSD-controlled air compressors have been available for more than 30 years, but only recently have they been packaged on new compressor systems and sold routinely by compressor vendors.[8] Atlas Copco and Ingersoll Rand are among the leaders, but Kaeser (a popular California brand), Quincy, and others now also offer VSDs. Considering their relatively recent mass introduction to the market, the 6 percent to 8 percent market saturation found in the survey is high and reflects aggressive promotion by vendors along with interest by buyers. These results are shown in Exhibit 3-42.

Exhibit 3-42. Air Compressor Part-Load Control—Other Than Throttle Modulation and Variable Speed Drives

Responses	2001–2002								2002–2003	
	SIC 20		SIC 35		SIC 36		SICs 20, 35, 36		SICs 21-34, 37-39	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
Percent of modulating compressor horsepower not controlled by a throttle valve	37.0%	6.3%	25.5%	4.2%	61.5%	4.6%	**40.4%**	3.1%	**33.4%**	12.0%
Percentage of modulating compressor horsepower controlled by variable speed drive	0.0%	0.0%	2.6%	2.1%	19.4%	1.3%	**7.6%**	0.8%	**5.7%**	1.8%

Owing to the criticality of having compressed-air availability, most plants have multiple backup compressors. For plants with multiple, unequal-sized compressors, automatic controls can make it easier to minimize part-load losses and rotate compressor use. The survey found that such controls are in 19 percent to 36 percent of facilities (Exhibit 3-43). Some small plants—less than 100 horsepower—and single compressor plants (excluding backup) do not require any sequencing, therefore, the proportion of sites using multi-compressor sequencing out of those sites for which it is technically applicable may be more than 50 percent, a substantial market penetration. For comparison, the 1998 DOE study reported that 4 percent of facilities had installed multiple-compressor sequencing controls in the last two years.

Exhibit 3-43. Air Compressor Part-Load Control—Multi-Compressor Sequencing

Question and Responses	2001–2002								2002–2003	
	SIC 20		SIC 35		SIC 36		SICs 20, 35, 36		SICs 21-34, 37-39	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
Use automatic controls to optimally sequence multiple air compressor operation										
Yes	42.1%	22.1%	19.1%	6.5%	51.6%	5.2%	**35.6%**	7.1%	**19.4%**	6.7%
No	57.3%	22.1%	79.5%	6.5%	38.9%	5.2%	**60.8%**	7.1%	**77.2%**	7.5%
Not Sure	0.6%	NA	1.0%	0.4%	9.0%	NA	**3.3%**	0.2%	**3.4%**	3.3%
Missing	0.0%	0.0%	0.4%	0.4%	0.5%	0.5%	**0.3%**	0.2%	**0.0%**	0.0%

There are many instances where compressed air-driven equipment is the only solution to meeting a plant need. However, in some instances, either pneumatic or electric equipment can be used. From the energy-use perspective, electric equipment is virtually always going to use less energy than the energy required by the compressor to drive the pneumatic tool; saving as much as 95 percent. Therefore, conversion from pneumatic equipment is a sign of aggressive action to reduce compressed-air costs, while the reverse is not. Exhibit 3-44 shows that the trend is flat to negative, meaning energy-savings conversions are not common. No matter how efficient compressed-air systems are, increasing demand for air will eventually increase use of electricity.

Exhibit 3-44. Conversion To/From Equipment Using Compressed Air

Responses	2001–2002								2002–2003	
	SIC 20		SIC 35		SIC 36		SICs 20, 35, 36		SICs 21-34, 37-39	
	Esti-mate	Std. Error	Esti-mate	Std. Error	Esti-mate	Std. Error	Esti-mate	Std. Error	Esti-mate	Std. Error
Percent of total compressor horsepower where pneumatic equipment replaced electric equipment in the last 2 years	14.1%	1.4%	4.0%	3.3%	11.1%	0.8%	**9.9%**	1.1%	**0.3%**	0.1%
Percent of total compressor horsepower where electric equipment replaced pneumatic equipment in the last 2 years	1.6%	0.5%	0.1%	0.1%	0.0%	0.0%	**0.6%**	0.2%	**0.1%**	NA

Maintenance staff attention to leaks can be a good indicator of staff sensitivity to energy costs not just in the compressed-air system, but in the plant as a whole. The Compressed Air Challenge educators emphasize routine leak elimination. It is also a kind of “leading indicator” regarding maintenance practices. Exhibit 3-45 shows that California manufacturers are proactive in leak management. Over half of them regularly search for leaks more than once per year. About one third have received a systematic air leak audit in the last two years. The survey instrument did not explicitly give or ask for the definition of “systematic,” but such an audit typically involves careful tracing of all compressed-air lines with an ultrasonic leak detector and is likely to involve an outside contractor.

Exhibit 3-45. Compressed-Air Leak Audit Activity

Questions and Responses	2001–2002								2002–2003	
	SIC 20		SIC 35		SIC 36		SICs 20, 35, 36		SICs 21-34, 37-39	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
How often do you search for air leaks?										
Never	0.0%	0.0%	5.3%	3.0%	6.2%	3.1%	**4.0%**	1.5%	**3.4%**	2.5%
When compressors start having trouble meeting requirements	49.7%	3.4%	5.1%	2.5%	7.7%	3.9%	**18.9%**	1.9%	**17.8%**	7.7%
Regularly but not often—once a year or less	18.4%	4.2%	9.1%	3.1%	20.7%	3.3%	**15.3%**	2.0%	**17.2%**	8.1%
Regularly—more than once a year	29.4%	4.7%	80.1%	3.3%	64.9%	3.2%	**60.7%**	2.1%	**61.4%**	10.2%
Not sure	0.0%	0.0%	0.4%	0.4%	0.0%	0.0%	**0.2%**	0.2%	**0.3%**	0.2%
Missing	2.5%	2.5%	0.0%	0.0%	0.6%	0.6%	**0.9%**	0.8%	**0.0%**	0.0%
Received systematic compressed-air leak audit in last 2 years										
Yes	18.4%	4.4%	71.1%	6.6%	25.7%	5.0%	**42.0%**	3.3%	**22.2%**	7.4%
No	81.0%	4.4%	28.9%	6.6%	69.4%	4.9%	**56.3%**	3.3%	**74.2%**	7.8%
Don't Know	0.6%	NA	0.0%	0.0%	5.0%	0.6%	**1.7%**	0.2%	**0.2%**	0.1%
Missing	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**	0.0%	**3.4%**	2.5%

This level of activity is comparable or slightly better than that found in a 1999 New England study and the previously noted DOE study.[9] In several instances, the questions asked in those studies paralleled questions asked in the CEC study.[10] Selected results from these two studies are included in Exhibit 3-46, next to the similar questions and results from the CEC study.

Exhibit 3-46. Comparison of CEC Results with Results From Other Studies Around the Country*

Other Study Findings		CEC Findings	
Query (Study)	Result	Query	Result (Phase)
Had a compressed air study done in last 2 years (NE)	7%	Has your system received a systematic air leak audit in the last 2 years?	43% (I) 23% (2)
Routinely check for leaks (NE)	58%	Routinely check for leaks more than once a year	61% (I) 17% (2)
Fixed leaks in last 2 years (DOE)	20%	Routinely check for leaks once a year or less	15% (I) 62% (2)
Reconfigured piping and filters to reduce pressure drops in last 2 years (DOE)	5%	Reduced pressure due to reconfiguring distribution system in the last two years	4.1% (I) 4.1% (2)

* CEC percentage results in this table exclude from the denominators of the population those responses that were "Don't know" or similar for the most appropriate comparison.

Exhibit 3-46 also compares distribution system changes, one other type of upgrade inquired about in both surveys. DOE estimated that 5 percent of manufacturers reconfigured piping and filters to reduce pressure drops and Aspen's Industry Energy End-User Survey indicated that about 4 percent of compressor horsepower was reconfigured. While the percentages are not high, this is a significant activity to undertake with a system that likely has not failed, and researchers believe it reflects a moderate level of activity.

3.3.6 Water Recovery and Reuse

Judging from comments made by respondents, industrial plant managers regard water use differently than the use of other resources and materials. In California, water is a community issue and can be a political lightning rod. Because run-off has health implications, it bears monitoring by environmental regulators that electricity use does not, at least not at the end-user's facility. The suppliers interviewed claimed that most water-recovery systems are designed to clean wastewater (not sanitary sewer waste) to a purity that rivals the original water supply.

Typically, water recovery and reuse is a component of the overall treatment of the wastewater for chemicals and other undesirable elements. According to the six suppliers interviewed, the cost-effectiveness of installing these systems is almost always associated with two issues: (1) lack of water supply; and (2) lack of a local wastewater treatment facility with capacity for additional discharge. Respondents further stated that end-user energy costs generally are not a consideration, and in fact, end-user energy costs may increase due to additional pumping requirements.

About one-eighth of sites have installed water recovery and reuse systems (Exhibit 3-47). Combined water and heat recovery systems are at less than 2 percent of all sites (11 percent of 11 percent in Phase 2, for example). "Environmental reasons" were cited by more respondents (59 percent to 72 percent) than any other reason for installing water recovery systems (Exhibit 3-48). Aspen interprets that response to mean U.S. Environmental Protection Agency (EPA) regulatory compliance concerns affected the decision more so than regard for ecology.

Exhibit 3-47. Proportion of Plants with Water Recovery, With and Without Heat Recovery

Responses	2001–2002								2002–2003	
	SIC 20		SIC 35		SIC 36		SICs 20, 35, 36		SICs 21-34, 37-39	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
Proportion of facilities with a water recovery and reuse system	13.3%	5.2%	11.3%	7.9%	19.3%	9.8%	**13.5%**	5.0%	**11.5%**	3.3%
Proportion of wastewater recovery systems that include heat recovery	11.5%	6.4%	0.0%	0.0%	0.0%	0.0%	**2.5%**	1.4%	**10.9%**	10.2%

Exhibit 3-48. Reason for Installing Wastewater Recovery

Questions and Responses	2001–2002								2002–2003	
	SIC 20		SIC 35		SIC 36		SICs 20, 35, 36		SICs 21-34, 37-39	
	Esti-mate	Std. Error	Esti-mate	Std. Error	Esti-mate	Std. Error	Esti-mate	Std. Error	Esti-mate	Std. Error
Reasons for installing the water reuse system. Check all that apply										
Lack of available water supply	12.4%	7.2%	2.9%	1.3%	1.1%	0.8%	**4.4%**	1.7%	**19.2%**	0.4%
High wastewater treatment costs	35.6%	7.7%	14.9%	8.0%	68.6%	2.7%	**36.6%**	4.2%	**12.8%**	7.8%
Local wastewater treatment facility out of capacity	5.6%	5.6%	1.1%	0.8%	0.3%	0.0%	**1.9%**	1.3%	**0.4%**	0.3%
Lack of local wastewater treatment facility	20.3%	8.1%	0.5%	0.5%	0.0%	0.0%	**4.7%**	1.8%	**2.9%**	2.2%
Energy costs	19.0%	7.8%	19.9%	3.0%	19.0%	1.2%	**19.4%**	2.2%	**31.6%**	7.8%
Energy supply concerns	14.0%	7.7%	1.2%	1.2%	0.0%	0.0%	**3.7%**	1.8%	**5.2%**	2.2%
Environmental concerns	63.6%	9.0%	83.0%	8.0%	61.3%	3.0%	**71.8%**	4.3%	**59.1%**	14.1%
Other	11.0%	7.8%	2.5%	0.0%	6.7%	3.0%	**5.7%**	2.0%	**36.2%**	14.1%
The most important reason for installation of the water reuse system										
None most important	W	W	W	W	W	W	**0.0%**	0.0%	**2.3%**	0.7%
Lack of available water supply	W	W	W	W	W	W	**5.2%**	3.7%	**38.5%**	0.0%
High wastewater treatment costs	W	W	W	W	W	W	**48.1%**	4.1%	**21.8%**	4.5%
Local wastewater treatment facility out of capacity	W	W	W	W	W	W	**3.6%**	3.6%	**0.0%**	0.0%
Lack of local wastewater treatment facility	W	W	W	W	W	W	**0.0%**	0.0%	**0.0%**	0.0%
Energy costs	W	W	W	W	W	W	**26.5%**	4.1%	**0.8%**	0.5%
Energy supply concerns	W	W	W	W	W	W	**0.0%**	0.0%	**0.0%**	0.0%
Environmental concerns	W	W	W	W	W	W	**15.2%**	0.7%	**9.8%**	4.5%
Other	W	W	W	W	W	W	**1.4%**	0.7%	**5.9%**	4.4%
Don't know	W	W	W	W	W	W	**0.0%**	0.0%	**20.9%**	0.0%

"W" = "Withheld" because small sample.

Still, 27 percent of respondents reported that energy costs were the most important reason for installing the water reuse system. Even allowing for the possible bias of respondents knowing surveyors were conducting an interview about efficiency-related issues, this seems to reflect a more positive view of possible wastewater-energy synergy than the suppliers expected.

As shown in Exhibit 3-49, virtually all respondents could estimate wastewater flow rates off site, yet more than half of those that have wastewater recovery systems in Phase 1 and more than one-third in Phase 2 could not estimate how much water they recover. It appears managers consider installation of water reuse systems without applying the same cost-effectiveness analysis associated with energy savings by thinking of it more as a cost of doing business than an investment. The potential avoided cost of litigation dwarfs any ongoing savings stream. Energy-savings benefits, realized either at the plant or at the water supply organization, were of secondary concern.

Exhibit 3-49. Average Wastewater Flow Rate for Facilities with Water Recovery Systems

Questions and Responses	2001–2002								2002–2003	
	SIC 20		SIC 35		SIC 36		SICs 20, 35, 36		SICs 21-34, 37-39	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
Approximate wastewater flow from this facility (gallons per day)										
Less than 10,000									**93.9%**	2.0%
10,001 to 25,000									**0.5%**	0.2%
Less than 25,000	61.5%	9.7%	97.7%	1.4%	30.0%	4.1%	**68.1%**	2.6%		
25,001 to 100,000	11.3%	7.1%	0.6%	0.6%	45.0%	0.0%	**17.1%**	1.6%	**0.2%**	0.1%
100,001 to 200,000	0.0%	0.0%	0.5%	0.5%	19.2%	0.8%	**6.4%**	0.4%	**0.4%**	0.2%
200,001 to 500,000	9.8%	5.6%	1.2%	1.2%	0.0%	0.0%	**2.7%**	1.4%	**1.3%**	1.2%
500,001 to 1,000,000	4.5%	3.0%	0.0%	0.0%	0.0%	0.0%	**1.0%**	0.7%	**0.0%**	0.0%
Over 1,000,000	5.5%	3.1%	0.0%	0.0%	0.0%	0.0%	**1.2%**	0.7%	**0.0%**	0.0%
Don't know	7.5%	5.5%	0.0%	0.0%	5.7%	4.2%	**3.5%**	1.8%	**3.6%**	1.6%
The flow of recovered water (% of wastewater flow)										
0 - 10%	0.0%	0.0%	0.0%	0.0%	16.5%	0.0%	**5.3%**	0.0%	**14.5%**	10.2%
11 - 30%	2.2%	1.3%	1.2%	1.2%	1.1%	0.8%	**1.4%**	0.7%	**0.0%**	0.0%
31 - 50%	4.5%	3.0%	1.7%	0.6%	0.8%	0.8%	**2.0%**	0.8%	**21.2%**	11.7%
51 - 70%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**	0.0%	**2.3%**	2.1%
71 - 90%	5.6%	5.6%	0.0%	0.0%	2.1%	0.0%	**1.9%**	1.2%	**2.0%**	0.9%
91 – 100%	6.6%	5.6%	75.2%	2.7%	4.6%	4.1%	**37.5%**	2.2%	**25.3%**	2.6%
Don't know	81.1%	7.8%	22.0%	2.9%	74.8%	4.3%	**51.9%**	2.6%	**34.7%**	10.5%

3.3.7 Electronic Control of Process Equipment

Aspen interviewed five electronic process control (EPC) experts prior to site data collection. Collectively, the EPC experts reported that there was little presence of energy management or load shedding used in process control. They also stated that controls are primarily installed for productivity, diagnostics, and quality issues. Energy was not believed to be an important concern. The predictions of the EPC experts were tested in the survey.

In the end-user interviews, EPC equipment was specifically defined as that which unloads or turns off process equipment when the equipment is not in use. HVAC and air compressor systems were excluded from consideration, even if they were used for clean room processing or industrial compressed air. With that definition, 5 percent to 13 percent of industrial customers have such controls. As can be seen in Exhibit 3-50, the controls manage substantial loads. The average controlled load is over 300 kilowatt and the reducible load exceeds 200 kilowatt. The data indicate a fairly substantial level of load control. This reflects a higher level of activity than might have been anticipated in pre-survey interviews. Note that the standard errors for these results are large.

Exhibit 3-50. Electronic Process Controls to Save Energy

Questions and	2001–2002	2002–2003

Responses	SIC 20		SIC 35		SIC 36		SICs 20, 35, 36		SICs 21-34, 37-39	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
Percentage of establishments with electronic controls that unload or turn off equipment	19.7%	8.2%	7.8%	3.9%	20.3%	9.7%	**13.2%**	3.6%	**5.1%**	1.9%
What is the approximate total electric demand of the process(es) under automatic control? (hp)	357	358	131	84	542	302	**320**	170	**499**	1,063
What is the approximate electrical demand that the controls can turn off to save energy? (hp)	286	392	79	75	244	81	**201**	171	**228**	386

3.3.8 Power Generation

Power generation was a special interest technology added to the survey that is indirectly related to energy efficiency. The key data extracted from the Public Database indicate the saturation of different types of on-site generation equipment, excluding emergency backup equipment. The most significant finding is that while only 2.2 percent of sites have on-site generation (Phase 2), 1.8 percent have plans to install generating capacity in the future (Exhibit 3-51). Given that this survey was conducted shortly after the "energy crisis," it will be interesting to assess if the saturation of on-site generation does nearly double in later years. In the meantime, power planners may want to consider at least a fraction of the intent in their statewide power planning.

Exhibit 3-51. Non-Emergency On-Site Generation

Responses	2001–2002								2002–2003	
	SIC 20		SIC 35		SIC 36		SICs 20, 35, 36		SICs 21-34, 37-39	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
Proportion with a power supply used regularly to generate electricity	0.2%	0.2%	0.0%	0.0%	3.8%	3.0%	**1.1%**	0.8%	**2.2%**	1.5%
Currently planning on installing additional generation capacity	W	W	W	W	W	W	**W**	W	**1.8%**	1.2%

W = Withheld

3.3.9 Maintenance Practices

The period encapsulated by the "in last two years" clause of Phase 1 and Phase 2 includes the winter of 2001 and the California energy crisis. Therefore, it comes as no surprise that facilities reported an increase in their efforts on energy-related issues over that period (Exhibit 3-52). Although the majority of facilities responded that maintenance efforts on energy-related issues have stayed the same, the percentage of facilities that reported an increase in maintenance efforts more than doubled from 2001–2002 to 2002–2003. Some of the larger firms are known to have participated in voluntary load reductions, turning non-critical lights and equipment off, rescheduling work to the night shift, and briefly shutting down operations on critical days.

Exhibit 3-52. Maintenance Effort on Energy-Related Issues

Question and Responses	2001–2002								2002–2003	
	SIC 20		SIC 35		SIC 36		SICs 20, 35, 36		SICs 21-34, 37-39	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
Over the last two years, has maintenance effort on energy-related issues such as compressed air, blowers, and lubrication, increased, decreased, or stayed the same?										
Increased substantially	1.7%	0.9%	0.8%	0.4%	0.4%	0.2%	**0.9%**	0.3%	**2.8%**	1.5%
Increased somewhat	21.6%	8.2%	18.4%	10.0%	16.0%	9.4%	**18.6%**	6.2%	**8.6%**	2.9%
Stayed the same	70.6%	9.1%	76.5%	10.6%	72.2%	10.6%	**74.2%**	6.7%	**87.8%**	3.2%
Decreased somewhat	0	0	0.1%	0.1%	7.8%	4.2%	**1.8%**	0.9%	**0.5%**	0.3%
Decreased substantially	0	0	4.0%	3.7%	0.3%	0.2%	**2.3%**	2.1%	**0.1%**	0.1%
Don't Know	6.1%	6.1%	0.3%	0.3%	3.2%	3.2%	**2.3%**	1.6%	**0.1%**	0.1%

Surveyors also sought data about maintenance practices on specific types of energy-using systems in the plants, such as compressed air, blowers, motors, and bearings. Respondents were asked to classify their maintenance activities into one of five categories:

- *As Needed*: Repair/replace upon equipment failure or significant loss of performance.
- *Unscheduled Preventive*: Service items on an ad-hoc basis at signs of trouble or check intermittently using rules of thumb to spot problems.
- *Limited Scheduled Preventive*: Follow a pre-determined maintenance schedule for all major systems and equipment.
- *Aggressive Preventive*: Maintain most or all equipment on a predetermined schedule. Track with computer program. May be done by internal or external contractor staff.
- *Predictive*: Monitor times and cycles of equipment using built-in monitoring devices, deploy predictive models to anticipate maintenance problems.

The responses to type of maintenance programs by equipment and SIC can be viewed in detail the Public Database. The results could not be legibly tabulated using the format of other exhibits in this section. Exhibit 3-53 generally summarizes the responses. The ranges represent the variation over different technologies for which the policy questions were asked.

Exhibit 3-53. Maintenance Policy

Maintenance Policy	Percentage of Responses By Maintenance Practice and SIC	Maintenance Practice with Highest Percentage
As Needed	18% to 61%	Motor belt replacement
Unscheduled Preventive	1% to 6%	Filters
Limited Scheduled Preventive	9% to 35%	Motor lubrication
Aggressive Preventive	6% to 23%	Motor lubrication
Predictive	0% to 2%	Steam traps & pressure regulators

The maintenance policy data show:

- "As Needed" is the largest category chosen in both phases.
- "Predictive" maintenance is rare.
- The percentages were similar for the 2001-02 and the 2002-03 groups.
- The maintenance training data show that the commitment to training maintenance personnel on energy-related matters tripled in Phase 2 compared to Phase 1. This could be an instance where the change is due to timing of the survey—Phase 2 followed the power crisis and Phase 1 was during it—rather than differences between SICs.

Proper belt replacement procedures, such as changing all belts together when multiple belt sets are used to drive a single shaft, can save small amounts of money at little cost or effort if maintenance staff is aware of the benefits. It also saves the effort of replacing a second belt shortly after the first one is replaced.[11] Almost two-thirds (65 percent) of facilities staff that could answer the question and for which it was applicable indicated that replacing all belts at the same time was a matter of standard procedure (Exhibit 3-54).

Exhibit 3-54. Belt Replacement Procedure Reported in the 2001–2002 Survey

Questions and Responses	SIC 20		SIC 35		SIC 36		SICs 20, 35, 36	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
Belt replacement procedure most often followed:								
Replace all belts at the same time	20.2%	8.0%	34.6%	11.5%	32.3%	9.3%	**30.9%**	6.9%
Replace all belts at the same time with a machine	11.9%	5.1%	26.9%	10.8%	14.7%	5.3%	**20.8%**	6.2%
Replace worn or broken belts	41.9%	10.9%	23.2%	9.5%	21.8%	6.5%	**27.2%**	6.0%
No belt-driven equipment	0	0	1.3%	1.3%	0.6%	0.6%	**0.9%**	0.8%
Not sure	0.9%	0.8%	4.0%	3.7%	3.2%	3.0%	**3.1%**	2.2%
Not applicable	25.1%	9.3%	9.9%	8.0%	27.4%	11.0%	**17.2%**	5.5%
Other	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**	0.0%

It has been suggested that promotion of automated lubrication systems represents a valuable energy-efficiency resource and that such systems are growing in popularity. Future administrations of this survey will reveal if the latter is true. In the meantime, it appears that auto-lubrication is not yet recognized by end-users for its energy-savings benefits. In most cases, it appears that facilities purchased new equipment that already had this feature installed. Rarely was it a retrofit option. Exhibit 3-55 shows that energy savings was neither a goal nor a realized benefit of auto-lubrication.

Exhibit 3-55. Auto-Lubrication Objectives and Benefits

Questions and Responses	2001–2002								2002–2003	
	SIC 20		SIC 35		SIC 36		SICs 20, 35, 36		SICs 21-34, 37-39	
	Est.	Std. Error	Est.	Std. Error	Est.	Std. Error	Est.	Std. Error	Est.	Std. Error
Why did your firm install the lubrication system(s)										
Reduce maintenance time spent manually lubricating	44.2%	5.2%	1.1%	0.9%	1.4%	0.3%	**8.4%**	1.1%	**5.6%**	1.4%
Reduce maintenance time/money spent on equipment repair	12.9%	5.0%	0.9%	0.4%	9.2%	0.3%	**3.8%**	0.9%	**4.9%**	1.2%
Increase equipment reliability or productivity	28.6%	5.4%	1.8%	0.9%	22.2%	20.1%	**8.5%**	2.5%	**5.6%**	1.3%
Energy savings	4.6%	3.6%	0.2%	0.0%	24.2%	20.1%	**3.5%**	2.3%	**0.6%**	0.3%
It came with new equipment being installed	47.8%	5.2%	98.3%	1.1%	86.1%	0.3%	**88.5%**	1.2%	**85.5%**	7.7%
Other	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.1%**	0.0%	**8.1%**	7.6%
Don't know	2.0%	2.0%	0.0%	0.0%	0.0%	0.0%	**0.3%**	0.3%	**0.3%**	0.3%
Have you realized any benefits of auto-lubrication since installation?										
Reduce maintenance time spent manually lubricating	48.6%	6.3%	17.5%	10.2%	28.2%	18.8%	**23.9%**	7.7%	**31.3%**	10.6%
Reduce maintenance time/money spent on equipment repair	58.9%	5.2%	5.2%	1.2%	13.9%	0.3%	**15.2%**	1.2%	**28.0%**	10.5%
Increase equipment reliability or productivity	23.7%	5.4%	7.1%	3.7%	25.2%	20.1%	**11.9%**	3.6%	**35.4%**	10.3%
Energy savings	0.0%	0.0%	1.6%	0.9%	3.7%	0.0%	**1.6%**	0.6%	**0.1%**	0.1%
Other	0.3%	0.0%	6.5%	4.2%	18.8%	18.8%	**6.8%**	3.7%	**19.3%**	5.9%
Don't know	4.2%	2.0%	70.0%	10.2%	22.7%	20.1%	**53.7%**	7.7%	**14.3%**	8.7%

Aspen also investigated auto-lubrication from the supply side, interviewing two vendors of automated lubrication equipment. Both vendors were uninformed about the function and market conditions of the automated lubrication products they sell, as lubrication devices are just a small part of larger diversified product offerings. Aspen therefore contacted two manufacturers directly (one customer service manager and one marketing manager) to discuss their products.

While it is undeniable that lubrication affects energy efficiency under all circumstances, the two managers considered the energy-savings potential of these systems to be "off of the radar screen" in terms of benefits. Maintenance labor savings and increased lubricated equipment reliability are considered to be far more important.

Programmatically, there are opportunities to advance the use of auto-lubrication systems, and thereby achieve energy savings, but it means starting from a base level of negligible awareness.[12]

The Public Database contains responses to sets of survey questions related to maintenance practices for various items of equipment. In general, the questions ask about "as needed" maintenance versus various levels of preventive and predictive maintenance. For example, the responses to questions for blowers disclosed that the majority of respondents cleaned the blades and balanced the fan wheels on an "as-needed" basis. Less than 20 percent, on average, performed aggressive preventive or predictive blower maintenance.

3.3.10 General Information

Two types of general information were gathered in the surveys:

- Firmographic data, such as size (expressed in terms of floorspace, employment, shift operations, and energy use) and business-activity trends
- Results that give indicators or energy-efficiency market share or practices that are not associated with any of the industrial technologies listed above

The Financial Accountability Barrier

Two barriers to the implementation of cost-effective energy-efficiency upgrades often cited by researchers are the:

- Financial disconnect between those who specify equipment that is purchased and those who pay the utility bills
- Lack of awareness by facilities staff of energy-efficiency issues

While the survey illustrates that these barriers exist, they may not be as formidable in 2003 as they were in the previous decade. For nearly half of all facilities, the specifying department is the same as the bill-paying department (Exhibit 3-56). This means that half of the time, the department that would choose to invest in energy efficiency would reap the benefits of that investment. Stratification by size would likely reveal that specifying and paying is consolidated more for the smaller customers than larger customers.

Exhibit 3-56. Financial Accountability Barrier

Questions and Responses	2001–2002								2002–2003	
	SIC 20		SIC 35		SIC 36		SICs 20, 35, 36		SICs 21-34, 37-39	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
Does the department that specifies equipment pay the electric bills out of their account?										
Yes	25.8%	10.1%	65.8%	10.4%	16.7%	5.7%	**45.3%**	6.2%	**45.8%**	6.0%
No	60.6%	11.5%	23.1%	5.4%	79.9%	6.1%	**44.8%**	4.2%	**33.2%**	5.3%
Other	6.5%	5.3%	10.7%	8.9%	3.4%	2.9%	**8.1%**	5.0%	**20.9%**	5.2%
Not sure	7.1%	6.6%	0.3%	0.3%	0.0%	0.0%	**1.8%**	1.5%	**0.1%**	0.1%

Energy-Related Training

Between 2000 and 2003, about 10 percent of all facilities have staff that received energy-efficiency training in the last two years (Exhibit 3-57). Considering the difficulty of finding time for busy plant engineers to attend training, the downturn that struck the California economy during the survey period, and the fact that energy is just one of many possible training topics for facilities staff, this is a moderately high proportion. This could be an instance where the change in results, an increase from 7 percent to 13 percent, is due to timing of the survey (Phase 2 followed the power crisis and Phase 1 was during it) rather than differences between SICs.

Exhibit 3-57. Recent Energy-Related Training

Question and Responses	2001–2002								2002–2003	
	SIC 20		SIC 35		SIC 36		SICs 20, 35, 36		SICs 21-34, 37-39	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
In the last two years have plant personnel received training that included a section on energy management practices?										
Yes	17.9%	8.4%	2.1%	0.6%	8.3%	3.7%	**6.9%**	2.0%	**13.0%**	3.4%
No	81.9%	8.4%	97.9%	0.6%	91.7%	3.7%	**93.1%**	2.0%	**86.8%**	3.4%
Not sure	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	**0.0%**	0.0%	**0.1%**	0.1%

Business Activity Trends

The economic downturn manifested itself in slightly reduced production, according to the respondents. Production decreases outweighed increases by 7 percent at facilities with continuing operations (Exhibit 3-58). Increases were more likely at larger facilities; decreases were more common at smaller facilities.

Exhibit 3-58. Production Changes, 2000 to 2003 Reported in the 2002–2003 Survey

Question and Responses	SICs 21-34, 37-39	
	Estimate	Std. Error
Has your overall production increased or decreased in the last 3 years?		
Increased	**32.0%**	5.3%
Decreased	**38.7%**	6.0%
No change	**28.8%**	5.6%
Refused to answer	**0.0%**	0.0%
Not sure	**0.5%**	0.3%

Lighting

Lighting is responsible for less than 15 percent of the typical industrial plant electricity bill. One question, “Please estimate the percentage of lighted floorspace by indoor lighting type” was added to the Phase 2 survey to address lighting technologies. The results showed that T8 lamps had only a 12 percent share of fluorescent lighting in 2003. This value is considerably smaller than three other data values pertaining to the prevalence of T8 lamps in nonresidential buildings at earlier time periods: (1) the T8 market share of 52 percent in commercial new construction lighting;[13] (2) the T8 saturation of 41 percent for all commercial facilities in California;[14] and (3) the nationwide average of about 50 percent.[15]

Plant Size

Historically, small businesses have been a large, yet difficult-to-reach, segment of the market in the commercial sector that offers substantial untapped energy savings potential. More than 74 percent of all commercial buildings in the United States are 10,000 square feet or less (22 percent of floorspace) and more than 98 percent are 100,000 square feet or less (68 percent of floorspace).[16]

Smaller industrial plants are likely to be similarly difficult-to-reach. Exhibit 3-59 suggests that the barrier is not as problematic in the industrial sector, where a comparatively lower 46 percent of plants are 10,000 square feet or less. The median facility size is 10,000 to 25,000 square feet. Because industrial facilities have higher energy intensities (Btu/sq.ft./yr) than commercial facilities overall, the potential problem is further mitigated. Overall, it indicates that industrial plants are good targets for efficiency outreach.

Exhibit 3-59. Industrial Facility Floorspace Reported in the 2002–2003 Survey

Question and Responses	SICs 21-34, 37-39	
	Estimate	Std. Error
Building square footage for the facility		
1,000 sq ft or less	**3.8%**	1.9%
1,001 - 10,000 sq ft	**42.3%**	5.9%
10,001 - 25,000 sq ft	**26.1%**	5.6%
25,001 - 50,000 sq ft	**14.3%**	4.3%
50,001 - 100,000 sq ft	**6.1%**	1.8%
100,001 - 250,000 sq ft	**3.2%**	0.5%
250,001 - 500,000 sq ft	**0.6%**	0.3%
Over 500,000 sq ft	**0.8%**	0.3%
Don’t know	**2.7%**	1.5%

3.3.11 Market Channels

How facility managers learned about energy efficiency was another area of interest to surveyors. Such data can help program designers optimize marketing resources to reach target audiences through the most effective channels. Questions were placed throughout the technology-specific subsections of the questionnaire to address this subject. The results are provided in Exhibit 3-60. For simplification of presentation, the results in this table do not include standard error. If the question was asked in both phases, the tabulated data are the averages of Phases 1 and 2 responses. Separate results for Phases 1 and 2, with standard errors, can be found in the Public Database.

Exhibit 3-60. Marketing Channels—Motors, Compressed Air, Electronic Process Control, Wastewater Recovery, and Power Generation

Question and Responses	Motors	Compressed Air	Wastewater Recovery	Electronic Process Control	Power Generation
How do you become aware of new products and product improvements?			*(Ph 2 only)*	*(Ph 2 only)*	*(Ph 2 only)*
Read about them in trade journals	48%	3%	59%	89%	72%
Sales personnel	44%	34%	33%	50%	10%
Utility/staff programs	6%	3%	8%	25%	1%
Business associates	9%	4%	6%	32%	1%
Trade shows	7%	NA	12%	34%	3%
Training	NA	NA	3%	27%	1%
Paid consultants	NA	NA	2%	26%	0%
Other	10%	3%	8%	25%	0%
Not sure	1%	1%	19%	0%	0%

The data suggest that the best way to expose end users to new ideas is through their trade journals, whether the outreach be advertising or placed articles. Even if the trade journals are distributed nationwide this might be a more economical means of initial exposure than some traditional channels, such as in-person training and trade shows. In fact, training was cited as a means of becoming aware of new products and improvements only about one-tenth as often as reading about them in journals. The results are generally consistent across technologies.

Sales staffs are the second-best channels. California energy-efficiency professionals have long worked with these allies, and the data indicate such efforts are worthwhile and should be continued.

Outsourcing of service functions has become common in the industrial sector as well as in the commercial world. Design and maintenance functions are contracted-out in some cases. Technology has become complex, increasing the need for outside experts to be contacted if any process changes are to be made. Still, on-site plant staff are more familiar with equipment than outside experts, and as Exhibit 3-61 shows, energy-efficiency ideas are suggested more often by internal staff than contracted individuals. The one exception to this was visible with Phase 2 wastewater, with more than half of energy-saving ideas being initiated by others. For simplification of presentation, the results in this table do not include standard error.

Exhibit 3-61. Sources of Ideas—Electronic Process Control and Wastewater Recovery

Question and Responses	Electronic Process Control		Wastewater Recovery	
	Phase 1	Phase 2	Phase 1	Phase 2
Who initiated the idea to install your equipment:				
We initiated idea and sought suppliers	47%	34%	44%	28%
Suppliers' representatives approached us	7%	29%	7%	12%
Corporate or other central-planning entity directed us to install or consider installing	3%	8%	6%	3%
Other	2%	29%	36%	57%
Don't know	0%	0%	8%	1%
Missing	41%	0%	0%	0%

Notes

[1] Efficiency Market Share Needs Assessment and Feasibility Scoping Study, Regional Economic Research, May 1999

[2] John E. Sugar, Program Planning & Process Energy Office of the California Energy Commission, September 29, 1998 (from letter to Mr. Robert Mowris regarding changes to Title 24 Building Efficiency Standards).

[3] Survey of 265 facilities conducted January through October 1997. "United States Industrial Electric Motor Systems Market Opportunities Assessment," for Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy, by Xenergy, Burlington, MA, December 1998, p. 48. This document can be downloaded from the Web by going to www.oit.doe.gov/bestpractices/motors/ and following the links to the PDF download.

[4] See "Industrial Technology Supplier/Expert Pre-Test Interview Results," Aspen Systems Corp, Submitted to CEC as part of this project, p. 4. See Appendix E for the complete report.

[5] Recommendation by R. Friedman, PG&E.

[6] A "significant gas user is a plant that that uses at least10,000 therms/yr of gas for industrial process heating, or has at least $5,000 per year of gas costs for this purpose.

[7] This is excerpted from Aspen's report prepared for the CEC in this project: "Industrial Technology Supplier/Expert Pre-Test Interview Results."

[8] Air compressor applications of variable speed drive have lagged pump and fan applications for two reasons: First, because most plant air compressors are positive displacement (screw or reciprocating) instead of dynamic (centrifugal), part-flow savings are generally not as high on a percentage basis as with fans and pumps. This increases payback time. Second, slowing rotor of a screw compressor below about 40 percent rated speed introduces the risk of reducing the effectiveness of oil as the seal between the compressor lobes and the housing. This decreases efficiency and risks machine damage. Manufacturers and vendors have not encouraged VSD retrofits. New compressor systems designed to work at variable speed have special features to prevent these problems.

[9] A group of New England utility companies commissioned a regional study on the state of industrial compressed-air efficiency in 1999. The study included a survey of 30 end users. "Compressed Air Systems Market Assessment and Baseline Study for New England, for Compressed-Air Study Group: Boston Edison, Commonwealth Electric, Eastern Utilities, Fitchburg Gas & Electric, New England Power Service Company, Northeast Utilities, by Aspen Systems Corporation, Rockville, MD, November 1999, p. 33-42.

[10] Those reports were reviewed in preparation of the CEC questionnaires.

[11] See http://www.gates.com/brochure.cfm?brochure=982&location_id=559 for more background information on this topic.

[12] This is excerpted from Aspen's report prepared for the CEC: "Industrial Technology Supplier/Expert Pre-Test Interview Results."

[13] Circa 1998. See the Non-Residential New Construction Baseline Study results in the Public Database.

[14] Market share from a 1997-98 study. Market share has risen since then. "PG&E and SDG&E Commercial Lighting Market Effects Study Final Report Volume I, Prepared for Pacific Gas & Electric and San Diego Gas & Electric, by Xenergy, Oakland, California, July 1998, p. E-5. Available from www.calmac.org, document No. 3903.

[15] "Magnetic ballasts/T12s now have about 50 percent of the national market for commercial/industrial fluorescent lighting, in 4-foot and 8-foot tubes." From "Battling Ballasts," in Pacific Northwest Conservation and Efficiency Newsletter, Energy NewsData, November 30, 1999. Available at http://www.newsdata.com/enernet/conweb/conweb47.html#cw47-8.

[16] Commercial building energy consumption survey (CBECS), Table B-3, Energy Information Agency, U.S. DOE, Washington, DC, August 2002. Available at http://www.eia.doe.gov/emeu/cbecs/detailed_tables_1999.html.

4. Data Collection and Analysis Methodology

4.1 Secondary Source Data Collection

4.1.1 Objective

The secondary data collection reviewed prior research studies from various sources to identify data sets that could be added to the Public Database. This review would be very useful in providing:

- Limited direct market share data
- Equipment shipments and control totals
- Market characterization attributes
- Market actor decision factors
- Technology prices
- Contextual information on markets and market mechanisms

The data sets reviewed were based on existing secondary data sources, and focused on the commercial-sector applications of four technologies:

- Lighting
- Windows
- Chillers
- Packaged air conditioners

Energy management systems were initially included, but subsequently dropped from both this task and the upstream market actor survey task to enable more resources to be applied to the other technologies. Additionally, the work scope included only limited treatment of packaged air conditions: the extraction and inclusion of data from the 2000 California Residential Market Share Tracking Study.

4.1.2 Overview of Approach

The secondary source research task was comprised of the three major subtasks:

- Generate a list of potential data sources that were believed to be good candidates, in addition to the required studies identified by the CEC.
- Review the CEC-approved material for content relevant to this study, which also included evaluating data quality.
- Extract the relevant information and place in finished data tables for inclusion into the Public Database.

The secondary sources generated two types of data. The first type included data that could be extracted directly from the source report in its current form and required no further analysis. For example, the 2000 California Residential Efficiency Market Share Tracking Study provided direct information on market share values for packaged air conditioning.

The second type of data required additional processing to be of value for this study. For example, the 1999 Non-Residential New Construction Baseline Study provided a wealth of information is its native form, but further processing of the raw audit data was required to generate market share values at various points of time, which was of principal interest for this study.

4.1.3 Secondary Sources Used

Appendix F provides a complete bibliography of all the studies reviewed as part of Task 3, including the studies specified by the CEC. Of the 40 sources reviewed, data from five studies are included in the Public Database (Exhibit 4-1). Typically, data from the reports or studies were input directly into the database along with available data-quality attributes. The largest exception to this method is the NRNC audit data from the 1999 NRNC Baseline Study. The baseline study provided a rich database of raw audit data for 990 new construction buildings spanning 1994 to 1998. Aspen analyzed the raw NRNC audit data and generated market share values for lighting, chiller, and window technologies.

Exhibit 4-1. List of Reports and Sources Reviewed for Task 3

Report Name	Sponsoring Organization	Author	Date Published	Summary
California Institute of Food and Agricultural Research Survey on Energy Management in the Food Industry	UC Davis	California Institute of Food and Agricultural Research	Aug-99	Six tables used in Public Database.
Nonresidential New Construction (NRNC) Baseline Study Final Report	SCE	RLW	Jul-99	Major source of data for the Public Database. Aspen computed over 6,000 market shares for lighting, window, and chiller technologies.
Database for Energy Efficiency (DEER) Update Study, Final Report and Ch. 5, Residential Measures	CEC	Xenergy	Aug-01	Cost and measure data for commercial lighting, window and chiller technologies included in Public Database.
C&I New Construction and Retrofit Lighting Design and Practices	SMUD	HMG	Oct-00	Study looks at efficient lighting practices in SMUD service territory. Three data tables included in Public Database.
California Residential Efficiency Market Share Tracking Study, HVAC 2000	SCE	RER	May-02	Data for quarterly and annual market shares of packaged air conditioner sales included in Public Database.

4.1.4 Data Quality Attributes

Exhibit 4-2 summarizes the data quality attributes fields that make up the Data Quality Table (tblDQA) in the Public Database. The data-quality attributes give the user of the data an indication of the reliability of the information or estimate. Secondary data included in the Public Database are linked to this table by the DQA_ID field. Where possible, data-quality attributes were extracted directly from the report or study. For the NRNC data, Aspen computed the data-quality attributes as part of the data analysis.

Exhibit 4-2. Data Quality Attribute Table Definition

Field Acronym	Full Name	Explanation
DQA_ID	DQA Identifier	Key field to join to data tables.
RespondentUncertainty	Respondent Uncertainty	Indicator of the respondent's uncertainty for selected items.
CollectMethod	Collection Method	Original data collection method (e.g., observed during on-site survey; reported by respondent during on-site survey; measured during on-site interview; reported during telephone interview; downloaded from utility billing files; extracted from company sales records; derived from other data elements; forecast from other secondary data sources.
ReportedStdErr	Standard Error	Measure of the random sampling error of the estimate as provided in the secondary data source consulted.
SamplBias	Sample Bias	Error due to non-response or incomplete response from a selective sample.
RespRate	Response Rate	Ratio of number of surveys completed to number attempted.
SamplMethod	Sampling Method	Field indicating: (1) simple random; (2) stratified random; (3) convenience; (4) census; (5) attempted census; (6) cluster; (7) multistage; (8) not reported; … etc.
No_Obs	Number of Observations	Reported number of observations.
SamplSize	Sample Size	Number, range, or not provided.
DataType	Type of data the estimation was based on	Categorical, truncated, continuous, Likert-scale, binary, or not reported.
EstMethod	Estimation technique	OLS, WLS, logit, tobit, simulation, GLS, logit with modification, average, weighted average, meta-analysis, synthesis of estimates other than through meta-analysis, judgmental, or not reported.

4.1.5 Data Analysis

4.1.5.1 Non-Residential New Construction Baseline Study (NRNC)

Conducted by RLW Analytics, Inc. (RLW) and Architectural Energy Corporation on behalf of the California Board for Energy Efficiency (CBEE) under the direction of Southern California Edison, this study was intended to give CBEE a set of baseline information that could be used by market planners in designing and evaluating programs to alter the behavior of the market actors in the NRNC market in California.

Two primary sources of data were used for the study: (1) qualitative surveys of designers of new buildings; and (2) on-site audits at 148 newly constructed buildings, conducted during 1998, along with similar audits from the following studies.

- 1994 SCE and PG&E joint NRNC program evaluation
- 1995 SDG&E NRNC program evaluation
- 1996 SCE program evaluation
- 1996 PG&E program evaluation

In total, 667 audited sites stratified by major building types were used to generate the bulk of the results. The study also provided a public database containing all the audit and DOE simulation data for 990 facilities. The additional 323 buildings were sites from the previous studies not included in the 1999 study. Exhibit 4-3 summarizes the distribution of sample points by utility service territory, building type, and year.

The NRNC database also included case weights for each of the sample points. The market share analyses for lighting, window, and chiller technologies were performed by Aspen with the basic assumption that the weights and associated basis values reported in the public NRNC database were representative of the California new construction market for the four years reported. Aspen contacted RLW and verified that the weights reported in the public NRNC database were current and could be used for computing market share ratios. A full discussion on the development of the sample weights is provided in the appendix of the 1999 NRNC study.

NRNC Lighting

Aspen computed market share values and standard error results for 16 lighting technologies:

- Biaxial
- Compact fluorescent
- Exit
- Sodium
- Incandescent
- Metal halide

Exhibit 4-3. Sample Size and Distribution for NRNC Data

Utility	Building Type	Year 1994	1995	1996	1998	Grand Total
PG&E	Office	56		47	26	**129**
	School	35		27	15	**77**
	Retail	14		44	17	**75**
	Public Assembly	14		15	16	**45**
	General C&I Work	22		47		**69**
	Medical/Clinical	17		17		**34**
	Grocery Store	7		26		**33**
	C&I Storage	15		14		**29**
	Restaurant	7		10		**17**
	Other	7		11		**18**
	Fire/Police/Jails	4		4		**8**
	Hotels/Motels	1		1		**2**
	All Buildings	**199**		**263**	**74**	**536**
SCE	Office	39		38	7	**84**
	School	55		20	10	**85**
	Retail	23		36	15	**74**
	Public Assembly	18		11	22	**51**
	General C&I Work	15		11		**26**
	Medical/Clinical	9		4		**13**
	Grocery Store	4		8		**12**
	C&I Storage	6		9		**15**
	Restaurant	11		11		**22**
	Other	12		4		**16**
	Fire/Police/Jails	2		2		**4**
	Hotels/Motels	2				**2**
	All Buildings	**196**		**154**	**54**	**404**
PG&E/SCE	**All Buildings**	**395**		**417**	**128**	**940**
SDGE	Office		10		8	**18**
	School		2		5	**7**
	Retail		8		5	**13**
	Public Assembly		7		2	**9**
	General C&I Work		2			**2**
	Medical/Clinical		1			**1**
	All Buildings		**30**		**20**	**50**
PG&E/SCE/SDGE	**All Buildings**	**395**	**30**	**417**	**148**	**990**

- Mercury
- Fluorescent
- Halogen
- T8 lamps with electronic ballast
- T8 lamps with magnetic energy saver ballast
- T12 lamps with electronic ballast
- T12 lamps with magnetic energy saver ballast
- T12 lamps with standard magnetic ballast
- T10 lamps with standard magnetic ballast
- T9 lamps with standard magnetic ballast

Market share values and standard errors for each lighting technology were computed using ratio estimation in SAS®, and the following five variables from the NRNC database:

- Sampling weight for the site
- Building type
- Estimated total lighting kilowatt load at site
- Estimated lighting technology kilowatt load at site (16 technologies)
- Utility service territory
- Year of study

Therefore, market share percentages provided in the Public Database are kilowatt ratios rather than simple proportions. Given the large sample size (990), Aspen was able to compute market share results from 1994 to 1998 for a wide combination of market segments. The first segmentation was by utility service territory in the following combinations:

- PG&E
- SCE
- SDG&E
- PG&E/SCE Combined
- PG&E/SCE/SDG&E Combined

The second segmentation was by the following Title 24 building types:

- Office
- School
- Retail
- Public assembly
- General C&I work
- Medical/clinical
- Grocery store
- C&I storage
- Restaurant
- Other
- Fire/police/jails
- Hotels/motels
- All buildings types combined

Once computed, the final market share results were uploaded into the Public Database for viewing via query screens.

NRNC Windows

The NRNC window technology data were processed using the same algorithms as the lighting data, differing only in the type of technology and the basis used to compute the market shares. The basis used to compute window technology market shares was total window area reported in square feet for each site. Market shares were computed by utility service territory, Title 24 building type, and the following nine window technologies:

- 1-Pane clear
- 1-Pane reflective
- 1-Pane tinted
- 2-Pane clear
- 2-Pane reflective
- 2-Pane tinted
- 3-Pane clear
- 3-Pane reflective
- 3-Pane tinted

NRNC Chillers

The NRNC database provided Aspen with a sample of 156 chillers installed in the new construction market segment from 1994 through 1998. In order to present the data in a meaningful manner in the Public Database, the sample data were stratified by chiller type and size with individual market shares and their associated standard errors computed using tonnage as a basis.

In addition, Aspen established three efficiency categories (low, medium, and high) to enhance data presentation. Typically, chiller equipment is rated by its compliance to the given standard at the time of purchase. Over time, the standard tends to change. This results in equipment that was thought to be efficient relative to an older standard, now being inefficient relative to the new standard. With this in mind, Aspen used the three efficiency categories to classify the chiller market shares relative to the period when the NRNC chiller data were collected.

As the relevant measure of efficiency, Aspen used kilowatt per ton of rated capacity, as is done in the Air-Conditioning and Refrigeration Institute's Standard 550/590 and California's Title 24 Energy Code. Aspen collected compressor kilowatt-per-ton data for 317 chillers available from the five major chiller manufacturers (i.e., data shown in current catalogs). The data were organized according to the type, size, and condenser-system type classification system as used by the standards.

Exhibits 4-4 and 4-5 graphically illustrate the results of the compilation. The exhibits plot both the chiller data and the pre- and post-10/29/01 minimum-efficiency standards. (In the case of the air-cooled chillers, the standard did not change and is not a function of chiller capacity.)

Exhibit 4-4. Efficiency Analysis Graph for Air-Cooled Chillers

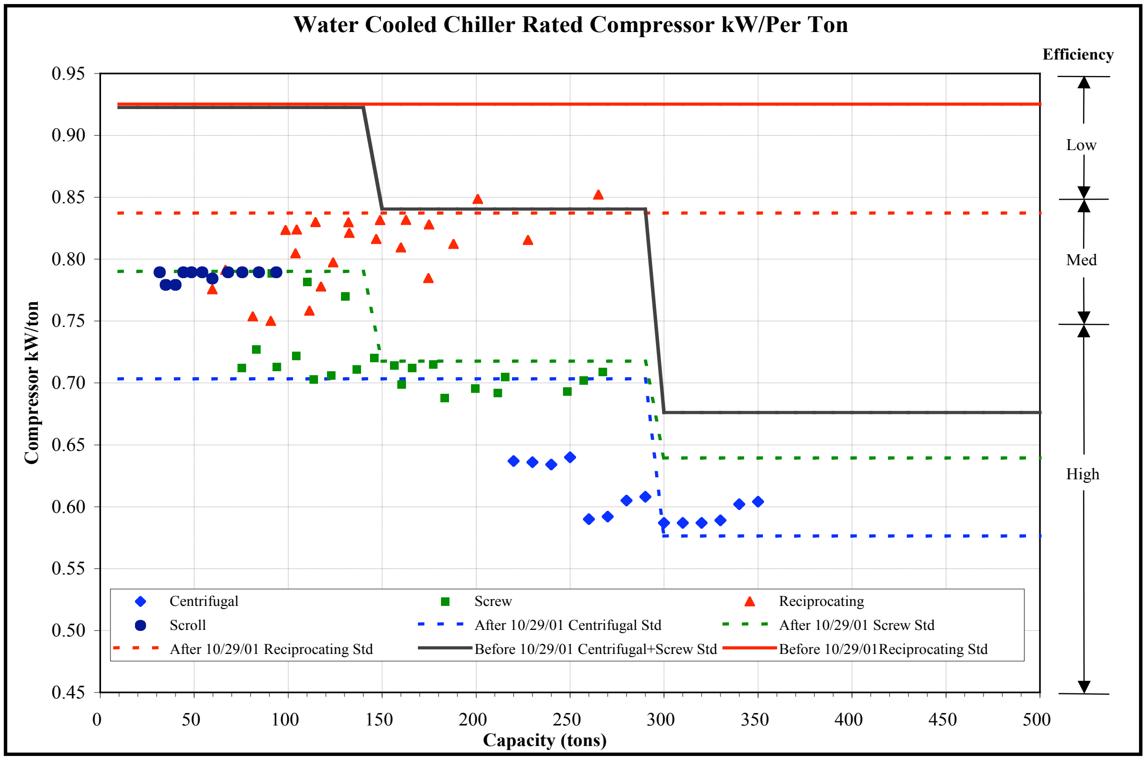
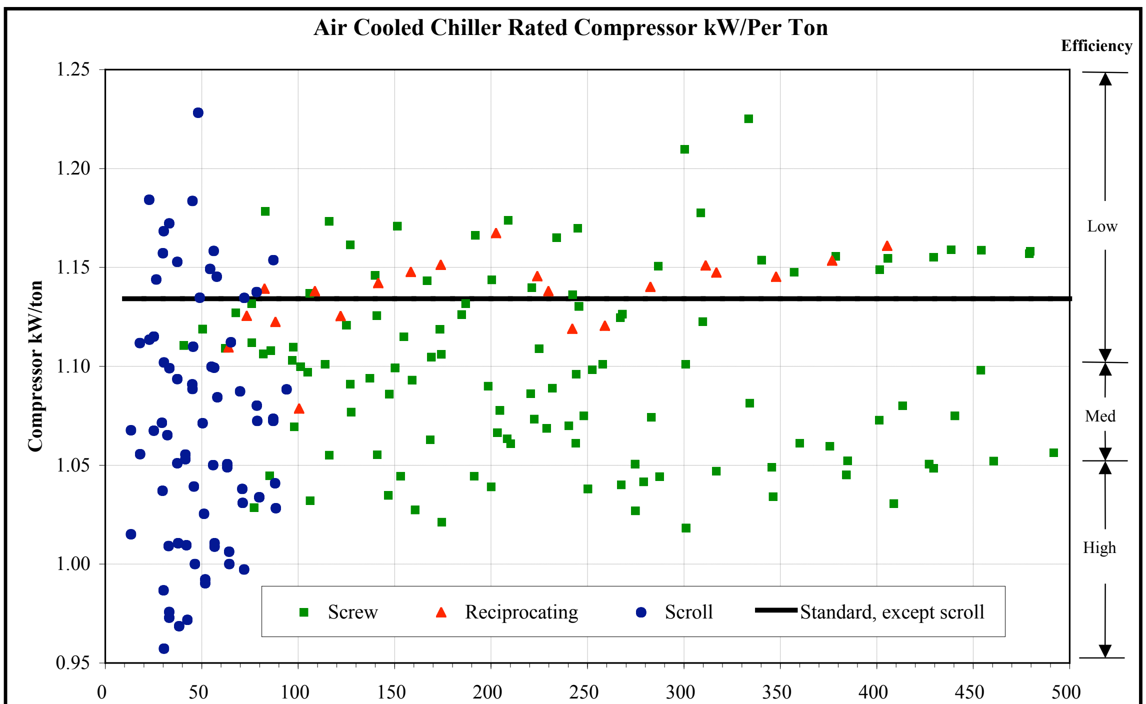


Exhibit 4-5. Efficiency Analysis Graph for Water-Cooled Chillers



Notes: (1) Scroll units not regulated by Standard
(2) Standard remained the same after 10/29/01

Aspen determined the ranges of the three efficiency categories based on a qualitative consideration of all the data and a general knowledge of chiller efficiency trends over the last eight years. The charts were then used to create the three efficiency levels for market share computations for each of three size groups. Exhibit 4-4 for the air-cooled chillers demonstrates how the sample of 238 air-cooled chillers manufactured today fall relative to the standard for that chiller type and within the Aspen-determined efficiency categories.

The efficiency categories for air-cooled units are as follows:

- Low: greater than 1.10 kW /ton
- Medium: between 1.10 and 1.05 kW/ton
- High: less than 1.05 kW/ton

Similarly, the efficiency categories shown in Exhibit 4-5 for water-cooled units are as follows:

- Low: greater than 0.85 kW/ton
- Medium: between 0.75 and 0.85 kW/ton
- High: less than 0.75 kW/ton

Market-share values computed from the NRNC data are presented in Chapter 3.

4.1.5.2 Database for Energy Efficiency Resources (DEER) Update Study

The DEER Update Study provides estimates of full and incremental costs for currently available residential and commercial technologies and energy-efficiency measures. The key purpose of this study was to create a common set of cost and savings data across California's major utilities to improve the consistency of information and assumptions used in energy-efficiency analyses.

Measure costs were estimated using over 8,000 cost quotes collected from distributors, contractors, and retailers throughout California. Cost data were collected from 318 sources. Cost estimates were segmented based on a number of characteristics, including distribution channel, volume, vintage, size, and efficiency.

The DEER cost data, provided in database form, is being used in the Public Database "as-is" except for the addition of data quality attributes and removal of data records pertaining to technologies not covered in the Aspen scope of work. Aspen has modified the DEER public database to only provide cost information on HVAC, window, chiller, and lighting technologies. Some modifications have been made to the query form and report to enhance user friendliness.

4.1.5.3 California Residential Efficiency Market Share Tracking Study

The California Residential Efficiency Market Share Tracking project is an ongoing study conducted by Regional Economic Research for SCE. The objective of the study is to present the market share of energy-efficient products over time within the California residential market, which includes air conditioning. For each type of HVAC equipment examined, the current state of efficiency standards is presented, including information regarding federal energy use standards, national ENERGY STAR® program standards, and California efficiency standards. The results presented in this report are based on data from 1999 through 2000. A subsequent annual report will present results based on data through 2001. At that point, reports will be available on a semi-annual basis.

Data from two tables are included in the Public Database and represent quarterly and annual estimates of market shares for Energy Star® qualified CAC sales in California at the state level, as well as by major utility service area.

4.1.5.4 C&I New Construction and Retrofit Lighting Design and Practices

The C&I New Construction and Retrofit Lighting Design and Practices commissioned by the Sacramento Municipal Utility District (SMUD) was undertaken to provide a market characterization assessment of SMUD's services relative to the rest of the state. Key objectives of the survey were to:

- Develop a baseline of current lighting design and retrofit practices for commercial and industrial customers
- Conduct market assessment of commercial and industrial lighting market
- Compare SMUD situation with other parts of California
- Present recommendations for future direction

The key findings of the report were:

- Major market players are owners/developers, designers, manufacturers' representatives
- SMUD's lighting programs are consistent with those of other utilities in region
- Market penetration of T8 lamps and electronic ballast in commercial market range from 50 percent to 75 percent with penetration of 75 percent to 80 percent for new construction
- The market for T8s in new construction has been transformed

The study results were generated using telephone surveys of a range of key market players, including:

- Manufacturers and distributors
- Lighting design community members
- Building officials
- Owners and developers
- Property managers

Three data tables were extracted from this study and are included in the NRMSTS Public Database.

4.1.5.5 California Institute of Food and Agricultural Research Survey on Energy Management in the Food Industry

The focus of the California Institute of Food and Agricultural Research Survey on Energy Management was to establish a baseline of information about energy issues in the agri-industrial processing sector and assess how energy management practices can increase profitability in a restructured electricity market.

Two focus groups were conducted with industry representatives to identify industry issues and to develop topics for the mail survey. The mail survey was sent to 170 facilities that were stratified by SIC sector and facility size class as measured by the number of employees (25-50, 50-100, and over 500). Facilities with 50+ employees, as well as SIC sectors with the largest electricity and natural gas consumption, were over sampled. There were 109 returned surveys from the sample of 170 facilities producing an overall response rate of 64 percent, with SIC sector response rates ranging from 54 percent to 88 percent. There is no evidence of non-response bias and an overall precision of 9 percent is reported for population proportions estimated from the survey data.
Six data tables containing information on energy management practices and decision factors were extracted from the study and are included in the Public Database.

4.1.5.6 Conclusions

Three types of data were extracted from secondary data sources and are stored in the Public Database:

- Data extracted directly from tables printed in the secondary sources and simply presented in the form shown in the original report. The packaged air conditioning data from the Residential Market Share Tracking Study is a good example of this type of data.
- Raw data extracted from supplementary databases provided as part of the secondary sources. These data are stored in raw form and presented to the user by means of a flexible query screen in the Public Database. The DEER data represents this type of data.
- Raw data that have been extracted from a secondary source database and reprocessed to provide meaningful information for the tracking study. For example, the reprocessed NRNC data provides the user of the Public Database with over 6,000 individual market shares for three technologies spanning four years.

Overall, the secondary data stored in the Public Database provides users with various forms and sources to assist in planning activities.

4.2 Industry Energy End-User Survey

4.2.1 Introduction

Aspen's Industry Energy End-User Survey data measure how often energy-efficient equipment is purchased in California's manufacturing plants, and how many plants have energy efficiency-oriented maintenance and purchasing policies. Only plants served by the state's three investor-owned utilities (PG&E, SCE, and SDG&E) were included in the survey. Data collection occurred in two phases:

- **Phase 1** focused on establishments in the three industries that are among the largest consumers of electricity in California:
    - Food Processing (SIC 20)
    - Industrial Machinery (SIC 35)
    - Electrical Equipment (SIC 36)

Data collection for this phase began in 2001, with most of the surveys completed during 2002 and a few completed in early 2003.

- **Phase 2** encompassed the other 17 SIC categories in the manufacturing sector (SICs 21-34 and 37-39). Data collection began in December 2002 and ended in June 2003.

The population of manufacturing firms from which the survey samples were selected was obtained from the electric-account billing files of PG&E, SCE, and SDG&E. These utilities include SIC code in account records, so this field was used to first identify manufacturing firms, and then to develop estimates of the sub-populations in each SIC category for purposes of sample design and selection. SIC codes were also used as a segmentation parameter in the data analysis. Aspen also identified the North America Industry Classification System (NAICS) code for each firm that provided data for the analyses.

Exhibit 4-6 lists the technologies for which Aspen collected data, and identifies the phase of the project during which data were collected.

Exhibit 4-6. Major Technology Subjects/Practices Covered in the Industrial On-Site Survey

Technology / Practice	Phase 1	Phase 2
Lighting (T8 and T12 fluorescent lamps only)	No	Yes
Electric Motors	Yes	Yes
Process Fluid Pumping	No	Yes
Variable Speed Drives	Yes	Yes
Compressed Air	Yes	Yes
Maintenance	Yes	Yes
Gas Process Heating	No	Yes
Blowers	Yes	Yes
Electronic Process Controls	Yes	Yes
Water Reuse and Recycling	Yes	Yes
Refrigeration	Yes	Yes
Power Generation	Yes	Yes

For each of the technologies in the table, Aspen collected data on market shares, quantities bought, decision factors, market pathways, costs, and applicable uses. Aspen also conducted an inventory of air compressors and gathered motor nameplate data on a random sample of up to 10 motors at each establishment visited.

The data collected are included in the Confidential Database (without data, such as name of company, telephone numbers, and contact information that would directly identify a respondent). Aspen also calculated summary statistics using these data, which are include in the Public Database.

4.2.2 Data Collection and Entry

4.2.2.1 Introduction

This section explains how samples of firms from whom data were collected were selected, how these firms were recruited, how the data collection forms were developed, what data-collection and data-entry procedures were followed, and what quality assurance (QA) and quality control (QC) procedures were implemented.

4.2.2.2 Phase 1 Sampling

For the first wave of data collection, Aspen, CEC, and utility stakeholders decided to focus on establishments in SIC codes 20, 35, and 36. These were selected based on data from *The Quarterly Fuel and Energy Report*. According to this report, SIC 20 was ranked first among 2-digit SICs in total GigaWatt hours consumed. It was also ranked fourth in new capital spending, suggesting that it was an industry with high potential for energy savings with purchases of new capital equipment. SIC 36 ranked second in total GigaWatt hours consumed and first in new capital expenditures, and SIC 35 ranked sixth in total GigaWatt hours consumed and third in new capital expenditures.

The universe for the Industry Energy End-User Survey in Phase 1 consisted of all in-scope manufacturing establishments located in the electricity service areas of PG&E, SCE, and SDG&E. The creation of the sampling frame and the sample selection for each utility is discussed below.

Phase 1 SCE Territory Sampling

Sampling Frame. Aspen defined the sampling unit for this survey as a manufacturing facility (site) at a given street address. Before sending the billing files to Aspen, SCE removed known non-building accounts and used an account-matching algorithm to aggregate accounts before sending the billing files to Aspen. SITEID variables identified aggregated accounts in the SCE billing files. SCE staff assigned negative SITEID variables to non-aggregated accounts. Site-level billing files in SAS format contained a total of 48,615 industrial customers having SIC codes ranging from 00 to 99. In addition to the account number and SITEID, the files contained: corporate name and site-level company name, facility SIC (FSIC), corporate SIC (SIC), service address, mailing address, rate class, annualized kilowatt-hour, and maximum annual billing kilowatt.

Selection of In-Scope Accounts. Aspen created a subset of the billing file, restricting the potential in-scope accounts to those with annual consumption of at least 1,000 kilowatt-hour and having a SIC or FSIC code of 20, 35, 36, or missing (not classified). This resulted in a dataset containing 9,960 records, of which 3,235 had missing SIC codes. To assign valid SIC codes to accounts where information was not provided, Aspen merged the accounts with missing SIC codes by company name with the commercially available *InfoUSA* file containing company-level data on California businesses. This merging process resulted in the assignment of in-scope SIC codes to 18 accounts with previously missing SIC or FSIC codes. At this point, we used FSIC rather than SIC as it reflects the type of industrial activity being performed at a particular service address. Any FSIC codes not equal to 20, 35, or 36 were out-of-scope and dropped. The resultant data set contained 6,378 records.

Account Matching. Examination of the service addresses for these records suggested that further aggregation of accounts might be necessary. Aspen examined a list of potential duplicates sorted by company name, service address, service city, and service zip code, and identified 50 sets of duplicate addresses. To be identified as a duplicate site address, accounts had to have the same service street number and street name and differ only in suite number designation. Aspen then aggregated the consumption data for the duplicate site addresses to the original site. A (0,1) flag variable identified all aggregated records in the sampling frame. The final site-level sampling frame contained 6,328 records.

Stratification Variables. Aspen stratified the sampling frame by FSIC and annual kilowatt-hour size class. The Dalenius-Hodges procedure[1], which is used to reduce estimate variances, permitted determining the kilowatt-hour size class stratum boundaries within each SIC code. The initial stratification scheme called for four size classes: Certainty, Large, Medium, and Small. The 35 establishments with the highest consumption were placed in each SIC in the

Certainty strata. However, this is a large number of accounts for a Certainty stratum. Aspen attempted to achieve a completed interview with each these establishments. Aspen believed it was prudent to change the Certainty strata, leaving only the seven largest establishments. The 28 next-largest accounts were assigned to a stratum designated as "Very Large." Since the distribution of annual kilowatt-hour is highly skewed, with a small number of Very Large accounts and a large number of Small accounts, the majority of accounts fell into the Small size stratum. A stratum identifier and consecutive survey ID number accompanied each record in the sampling frame.

Exhibit 4-7 provides stratum population consumption means and coefficients of variation (CV). As can be seen, the stratification resulted in much lower CVs than exhibited by the overall population. Thus, it is likely the goal of variance reduction was achieved in summary statistics estimates of data later collected.

Ninety-five percent confidence intervals were constructed on the sample means for each cell. The population mean fell within the 95 percent confidence interval for all cells except SIC 36, small size class. To decrease the stratum variance in the sampling frame, Aspen used the Dalenius-Hodges procedure to split the Small stratum into a Very Small and a Small stratum for SIC 36.

Exhibit 4-8 shows sample consumption means by stratum. The desired draw within each cell for each sample was about four to five times the target sample count. In the cells where the population count was less than four to five times the target sample count, all observations were selected into the primary sample.

Exhibit 4-13 in a later section shows target numbers of completed on-site surveys for all three utility service territories. To achieve those targets for the SCE territory, a primary (n=429) and secondary sample (n=324) were taken. The secondary sample was used as a backup in the event that the primary sample did not provide sufficient numbers of establishments in each stratum agreeing to the on-site survey.

Exhibit 4-7. Phase 1 SCE Territory Sampling Frame Statistics

SIC	Size Class	N	Average Consumption (kWh) 11/99–10/00	Coefficient of Variation (kWh)
20	Certainty	7	40,373,739	63
	Very Large	28	12,450,096	25
	Large	97	4,733,438	36
	Medium	122	1,430,133	36
	Small	692	153,141	113
Total		**946**	**1,449,061**	**322**
35	Certainty	7	16,371,094	72
	Very Large	28	4,451,798	29
	Large	144	1,424,230	41
	Medium	475	343,705	44
	Small	3,304	38,085	103
Total		**3,958**	**185,303**	**514**
36	Certainty	7	85,131,802	52
	Very Large	28	12,799,394	50
	Large	80	4,002,070	32
	Medium	204	1,092,369	49
	Small	363	241,908	47
	Very Small	742	33,741	80
Total		**1,424**	**1,130,732**	**613**
Grand Total		**6,328**	**586,979**	**658**

Exhibit 4-8. SCE Territory Population and Sample Consumption Means by Stratum

SIC	Size Class	Population Mean Consumption (kWh)	Primary Sample Mean Consumption (kWh)	Secondary Sample Mean Consumption (kWh)
20	Certainty	40,373,739	40,373,739	—
	Very Large	12,450,096	12,450,096	—
	Large	4,733,438	4,769,626	4,398,160
	Medium	1,430,133	1,306,996	1,488,658
	Small	153,141	126,218	177,417
35	Certainty	16,371,094	16,371,094	—
	Very Large	4,451,798	4,451,798	—
	Large	1,424,230	1,573,178	1,428,919
	Medium	343,705	321,835	360,333
	Small	38,085	37,487	45,417
36	Certainty	85,131,802	85,131,802	—
	Very Large	12,799,394	12,799,394	—
	Large	4,002,070	3,928,761	3,940,997
	Medium	1,092,369	1,008,911	1,097,746
	Small	241,908	255,381	167,771
	Very Small	33,741	35,139	20,152

Note: All electricity consumption means (kWh) reflect annual data, i.e. kWh/yr, unless otherwise noted.

Phase 1 SDG&E Territory Sampling

Sampling Frame. SDG&E provided billing file information in a Microsoft ACCESS database containing two tables. All gas accounts were out-of-scope and dropped, as were non-building electric accounts identified by their rate code, such as traffic lights, residential, and agricultural. Also dropped were duplicate records by account number, service point ID, and meter read date, as identified in the billing information file, after aggregating the consumption across account number, service point ID, and meter read date. The resulting billing information file contained 78,605 records.

Annualizing Kilowatt-Hour. Since annual kilowatt-hour was a stratification variable, a full year of billing data was the ideal. During the creation of the sampling frame, Aspen included only active accounts, with the last bill required to be in February 2001 or later. Also, to maximize the number of accounts available for sampling, at least nine months of consumption were required for inclusion in the sampling frame. Data for the missing months were imputed using the data from the previous September, October, and November. Consumption for all accounts was normalized to 365.25 days. Annualized consumption was summed across all service points within an account to obtain account-level consumption. Any account having total annualized consumption less than 1,000 kilowatt-hour was dropped. The resulting data set contained 1,702 records.

Account Matching. An account matching algorithm was developed and used for a data set extract of potential duplicates based on customer name, service city, and customer telephone number. The algorithm matched accounts having the same service street number and street name and differing only in suite number designation. The annualized consumption was aggregated for the matched accounts. All records were assigned a (0,1) flag variable indicating whether accounts had been aggregated. After the matching was completed, the frame contained 1,263 records.

Stratification Variables. The sampling frame was stratified by FSIC and annual kilowatt-hour size class. The initial stratification scheme called for four size classes: Certainty, Large, Medium, and Small. Based on the univariate distribution of annual kilowatt-hour for each SIC class, the observations with the largest analyzed consumption, those significantly larger than the rest (outliers), were selected into the Certainty strata. The Dalenius-Hodges procedure was used to determine the remaining stratum boundaries. Both a stratum identifier and survey ID number were assigned to each record in the sampling frame.

Exhibit 4-9 provides stratum consumption means and CVs. As can be seen, the stratification resulted in much lower CVs than exhibited by the overall population. Thus, it is likely that the goal of variance reduction was achieved in summary statistics estimates of data later collected.

Exhibit 4-9. Phase 1 SDG&E Territory Sampling Frame Statistics

SIC	Size Class	N	Average Consumption (kWh) Spring '00–Spring '01	Coefficient of Variation
20	Certainty	2	W	5
	Large	15	1,802,209	96
	Medium	21	235,275	34
	Small	106	37,613	89
Total		**144**	W	**350**
35	Certainty	2	W	44
	Large	17	3,007,623	78
	Medium	83	409,613	48
	Small	560	34,872	109
Total		**662**	W	**648**
36	Certainty	3	W	27
	Large	17	4,865,216	52
	Medium	60	1,083,022	47
	Small	377	85,331	127
Total		**457**	W	**376**
Grand Total		**1,263**	**355,552**	**472**

W = Withheld

Exhibit 4-13 in a later section shows target numbers of completed on-site surveys for all three utility service territories. A primary (n=230) and secondary sample (n=141) were drawn to provide sufficient sample to obtain the target number of completed interviews per SIC class, kilowatt-hour size class cell. The desired draw within each cell ranged from about seven to nine times the target sample count. In the cells where the population count was less than the size of the desired draw, all available observations were selected into the primary sample and those cells were not represented in the secondary sample. Ninety-five percent confidence intervals were constructed on the sample means for each cell. The population mean fell within the 95 percent confidence interval for all cells. Exhibit 4-10 shows population and sample consumption means.

Exhibit 4-10. Phase 1 SDG&E Territory Population and Sample Consumption Means by Stratum

SIC	Size Class	Population Mean Consumption (kWh)	Primary Sample Mean Consumption (kWh)	Secondary Sample Mean Consumption (kWh)
20	Certainty	W	W	-
	Large	1,802,209	1,802,209	-
	Medium	235,275	235,275	-
	Small	37,613	47,771	34,718
35	Certainty	W	W	-
	Large	3,007,623	3,007,623	-
	Medium	409,613	429,134	400,634
	Small	34,872	40,442	34,985
36	Certainty	W	W	-
	Large	4,865,216	4,865,216	-
	Medium	1,083,022	1,068,883	1,104,232
	Small	85,331	78,183	78,371

Phase 1 PG&E Territory Sampling

Sampling Frame. PG&E provided a SAS Transport file containing billing information from June 2000 through May 2001 for 7,043 accounts. Specific fields included account number, customer name, billing address, service address, telephone number, FSIC, premise ID and monthly data on billed and metered kilowatt, number of days in billing period, bill from date and bill end date, and billed kilowatt-hour.

Annualizing Kilowatt-Hour. To screen out inactive accounts, Aspen dropped any accounts with less than nine months of consumption data. For those accounts with less than a full year of consumption readings, it was not possible to impute values for missing summer readings from past consumption because data were not available for the previous summer. Instead, the average daily consumption for each account was multiplied by 365.25 to obtain the normalized kilowatt-hour. The resulting data set contained 6,589 records.

Account Matching. Rather than using the PG&E-supplied premise ID, which was described as being out-of-date and of uncertain accuracy by PG&E's IT support personnel, the same account-matching algorithm used for SDG&E was applied to the entire sampling frame. The algorithm matched accounts having the same service street number and street name, aggregating accounts with different suite number designation at the same street address. The annualized consumption was aggregated for the matched accounts. A (0,1) flag variable was created to identify aggregated accounts. Aspen dropped accounts where the aggregated consumption was less than 1,000 kilowatt-hour. After completion of account matching, the frame contained 5,142 records.

Stratification Variables. The PG&E sampling frame was stratified by FSIC and annual kilowatt-hour size class. Five annual kilowatt-hour size classes were used: Certainty, Large, Medium, Small, and Very Small. Establishments with very large consumption values relative to the other establishments were placed in Certainty strata. The Dalenius-Hodges procedure enabled determination of the remaining stratum boundaries. Exhibit 4-11 shows the resulting stratum means and CVs.

Exhibit 4-11. Phase 1 PG&E Territory Sampling Frame Statistics

SIC	Size Class	N	Average Consumption (kWh) 6/00–5/01	Coefficient of Variation
20	Certainty	2	W	18
	Large	29	24,048,932	31
	Medium	84	8,651,750	32
	Small	257	2,103,991	57
	Very Small	1,397	130,610	130
Total		**1,769**	**W**	**324**
35	Certainty	2	W	78
	Large	19	22,395,582	54
	Medium	76	5,046,437	43
	Small	236	1,072,550	51
	Very Small	2,078	64,240	136
Total		**2,411**	**W**	**970**
36	Certainty	4	W	16
	Large	22	17,749,152	34
	Medium	113	4,408,765	36
	Small	180	1,473,842	34
	Very Small	643	167,025	111
Total		**962**	**W**	**292**
Grand Total		**5,142**	**1,024,410**	**514**

Exhibit 4-13 in a later section shows target numbers of completed on-site surveys for all three utility service territories. To achieve those targets for the PG&E territory, a primary (n=420) and secondary sample (n=342) were randomly selected within stratum from the population frame. The secondary sample was drawn as a backup in the event that the primary sample did not provide sufficient numbers of establishments in each stratum agreeing to the on-site survey. The desired draw within each cell ranged from about three to four times the target sample count. If the population count was less than the size of the desired draw in a cell, all available accounts were selected into the primary sample and those cells were not represented in the secondary sample.

Ninety-five percent confidence intervals were constructed on the sample means for each cell. The population mean fell within the 95 percent confidence interval for all cells, providing evidence the sample was representative of the PG&E population.

Exhibit 4-12 shows population and sample consumption means.

Exhibit 4-12. Phase 1 PG&E Territory Population and Sample Consumption Means by Stratum

SIC	Size Class	Population Mean Consumption (kWh)	Primary Sample Mean Consumption (kWh)	Secondary Sample Mean Consumption (kWh)
20	Certainty	W	W	-
	Large	24,048,932	24,048,932	-
	Medium	8,651,750	8,880,645	8,200,474
	Small	2,103,991	2,454,212	2,133,384
	Very Small	130,610	106,400	90,425
35	Certainty	W	W	-
	Large	22,395,582	22,395,582	-
	Medium	5,046,437	4,882,635	5,293,406
	Small	1,072,550	1,065,453	1,199,823
	Very Small	64,240	45,364	51,032
36	Certainty	W	W	-
	Large	17,749,152	17,749,152	-
	Medium	4,408,765	4,555,304	4,776,279
	Small	1,473,842	1,524,692	1,395,920
	Very Small	167,025	213,138	133,246

W = Withheld

Phase 1 Target Number of On-Site Surveys

Exhibit 4-13 shows the initial (pre-reductions) target number of completed on-site surveys and numbers of observations drawn by stratum for recruiting.

Exhibit 4-13. Phase 1 Sampling and Original Target Number of On-Site Surveys

	Size Class	N	Target Onsites	Number Drawn for Recruiting
PG&E				
20	Certainty	2	2	2
	Large	29	13	29
	Medium	84	15	72
	Small	257	16	72
	Very Small	1,397	17	72
Subtotal		1,769	63	247
35	Certainty	2	2	2
	Large	19	13	19
	Medium	76	15	72
	Small	236	16	72
	Very Small	2,078	16	72
Subtotal		2,411	62	237
36	Certainty	4	4	4
	Large	22	13	22
	Medium	113	15	72
	Small	180	16	72
	Very Small	643	16	108
Subtotal		962	64	278
Area Subtotal		5,142	189	762
SCE				
20	Certainty	7	7	7
	Very Large	28	8	28
	Large	97	8	72
	Medium	122	8	72
	Small	692	8	72
Subtotal		946	39	251
35	Certainty	7	7	7
	Very large	28	8	28
	Large	144	8	72
	Medium	475	8	72
	Small	3,304	8	72
Subtotal		3,958	39	251
36	Certainty	7	7	7
	Very Large	28	8	28
	Large	80	8	72
	Medium	204	8	72
	Small	363	6	25
	Very Small	742	5	47
Subtotal		1,424	42	251
Area Subtotal		6,328	120	753
SDG&E				
20	Certainty	2	2	2
	Large	15	4	15
	Medium	21	4	21
	Small	106	4	54
Subtotal		144	14	92
35	Certainty	2	1	2
	Large	17	4	17
	Medium	83	4	72
	Small	560	4	54
Subtotal		662	13	145
36	Certainty	3	2	3
	Large	17	4	17
	Medium	60	4	60
	Small	377	4	54
Subtotal		457	14	134
Area Subtotal		1,263	41	371

Size Class	N	Target Onsites	Number Drawn for Recruiting
Grand Total	**12,733**	**350**	**1,886**

4.2.2.3 Phase 2 Sampling

In Phase 2, Aspen surveyed the general manufacturing sector population, excluding the industrial segments surveyed in Phase 1. This was done because:

- The greatest potential for consumption reduction may be in mid- to low-energy consuming industries. Top-consuming industries may already have relatively high energy-efficiency market shares due to relatively high energy-cost pressures.
- A better picture of the California industrial market as a whole would be obtained.
- When stratifying by utility by consumption size class by SIC group, stratum populations often became too small.

Billing File Processing

Because each utility's billing files were formatted in a different manner, different procedures were required to process them into sampling frames. Aspen used certain general steps relating to account matching and stratification for all the files.

Account Matching. Aspen developed algorithms for each utility's files to match accounts having the following characteristics: [2]

- Similar customer name
- Same service street number and street name, differing only in suite number or letter designation

Annualized consumption from the matched accounts was aggregated and placed into one observation.

Deletion of Out-of-Scope Accounts. Aspen deleted from the frame matched accounts without at least one location with a valid FSIC code (21-34, 37-39). Also dropped were out-of-scope accounts as identified by their rate code, such as for traffic lights, other outdoor lighting, residences, and agriculture. Matched accounts with aggregate annual consumption of 1,000 kilowatt-hour or less were also dropped because any location with such a small load was highly unlikely to be a manufacturing establishment. Even if the location was a manufacturing establishment, program planning aimed at reducing its consumption is not worthwhile. Any account with only gas consumption was also dropped.

Stratification. Stratification was carried out on three dimensions: (1) utility service area; (2) electric consumption; and (3) age of accounts.

Because this is a market study, special attention was paid to accounts with less than nine months of consumption data. New accounts that contributed more than 25 percent to the total aggregated consumption for an aggregated record were assigned to the "Young Accounts" group. All other aggregated records were assigned to the "Established Accounts" group.

By segmenting new accounts with relatively few months of building data from more established accounts, Aspen avoided contaminating established accounts group with accounts that were annualized based on little data – and thus likely to be more unreliable. For this reason, very new accounts were deleted in Phase 1. In addition, Aspen had concerns that the facilities represented by these young accounts were not fully operational. However, in Phase 2, it was reasoned that establishments with a large percentage of consumption from new accounts might be very active in purchasing equipment. Segmenting young from established accounts allowed Aspen to:

- Target those perhaps highly active industrial customers
- Avoid potential problems caused by contaminating established accounts strata with accounts with highly speculative annualized consumption

Aggregated accounts were also stratified based on electrical consumption within each utility territory. For the established accounts groups, Aspen used five annual kilowatt-hour size classes: Certainty, Large, Medium, Small, and Very Small. The largest outlier accounts (in terms of electric consumption) were selected into the Certainty strata. The Dalenius-Hodges procedure, used to reduce variances of estimates, enabled determination of remaining stratum boundaries.

Phase 2 SCE Territory Sampling

SCE provided site-level billing files for a total of 47,731 account records with SIC codes ranging from 00 to 99. In addition to the account number and SITEID, SCE provided corporate name and site-level company name, FSIC, corporate SIC, service address, mailing address, rate class, annualized kilowatt-hour, and maximum annual billing kilowatt. SCE removed accounts known to be non-building accounts and did some account matching to aggregate accounts to the site-level before sending files to Aspen. Aggregated accounts in the SCE billing file were identified by the SITEID variable. After the account matching, aggregation, and deletion process, the frame contained 16,142 records. The results of the stratification procedures are provided in Exhibit 4-14. As can be seen, the stratum CVs are much lower than the overall CV, suggesting that variance reduction in estimates is highly likely if establishments vary in energy-efficiency behavior depending on size.

Exhibit 4-14. Phase 2 Sampling Frame Statistics for SCE Territory

	Size Class	N	Mean Annulaized Consumption (kWh)[3]	CV
Established Accounts	Certainty	15	196,554,947	70
	Large	120	22,887,661	66
	Medium	541	4,694,482	41
	Small	1,579	1,088,967	48
	Very Small	13,275	75,865	139
Subtotal		15,530	705,805	1,103
Young Accounts	Certainty	1	W	--
	Large	148	391,567	160
	Small	463	24,501	81
Subtotal		612	W	461
Total		16,142	W	1,116

W = withheld

Exhibit 4-15 shows population and sample consumption means for the SCE territory by stratum.

Exhibit 4-15. Phase 2 Population and Sample Consumption Means for SCE Territory by Stratum

	Size Class	Population Mean kWh/yr	Primary Sample Mean kWh/yr	Secondary Sample Mean kWh/yr
Established Accounts	Certainty	196,554,947	196,554,947	—
	Large	22,887,661	23,012,374	—
	Medium	4,694,482	4,767,902	5,144,645
	Small	1,088,967	1,086,597	990,950
	Very Small	75,865	82,060	76,831
Young Accounts	Certainty	W	W	—
	Large	391,567	369,187	—
	Small	24,501	24,375	24,355

W = Withheld

Exhibit 4-20 in a later section shows target numbers of completed on-site surveys for all three utility service territories. To achieve those targets for the SCE territory, a primary (n=1,024) and secondary sample (n=340) were randomly selected within stratum from the population frame. The secondary sample was drawn as a backup in the event that the primary sample did not provide sufficient numbers of establishments in each stratum agreeing to the on-site survey. If the population count was less than the size of the desired draw in a cell, all available accounts were selected into the primary sample. Please note that during the preparation for recruiting (directory assistance lookup, mailing of announcement, etc.), certain incidences of out-of-scope or misclassified status were detected and corrected. Therefore, population counts by stratum or in total may vary slightly between Exhibit 4-14 and Exhibit 4-20.

Phase 2 SDG&E Territory Sampling

Similar to Phase I, SDG&E provided its billing file information in a Microsoft ACCESS database containing two tables. One table contained account number, FSIC, numbers of electric and gas meters, customer name, telephone, billing address, and service address. This table had 10,254 records. The other table contained account number, service point ID, meter read date, bill year and month, service type (electric or gas), rate code, days in billing period, consumption, and demand. This table contained 364, 465 records.

Duplicate records by account number, service point ID, and meter read date were identified in the billing information file. Duplicates were deleted after aggregating the consumption across account number, service point ID, and meter read date. The resulting billing information file contained 364,185 records.

Since annual kilowatt-hour was a stratification variable, ideally one would want a full year of billing data. During the creation of the sampling frame, Aspen attempted to identify inactive accounts and delete them. Thus, any account whose last bill was prior to March 2002 was dropped. Consumption for all accounts was normalized to 365.25 days. Annualized consumption was summed across all service points within an account to obtain account-level consumption.

Aspen conducted account matching, aggregation and deletion previously described. The resulting frame contained 3,361 observations. Stratification resulted in groupings with the characteristics shown in Exhibit 4-16. As can be seen, the stratum CVs are much lower than the overall CV, suggesting that variance reduction in estimates is highly likely if establishments vary in energy-efficiency behavior depending on size.

Exhibit 4-16. Phase 2 Sampling Frame Statistics for SDG&E Territory

	Size Class	N	Mean Consumption	CV
Established Accounts	Certainty	2	130,949,481	97
	Large	22	11,162,222	61
	Medium	112	2,068,513	49
	Small	307	476,676	45
	Very Small	2,763	37,825	123
Young Accounts	Certainty	4	24,168,605	77
	Large	21	2,252,339	70
	Small	130	83,621	172
Total		3,361	998,995	469

Exhibit 4-17 presents population and sample consumption means for the SDG&E territory by stratum.

Exhibit 4-17. Phase 2 Population and Sample Consumption Means by Stratum for SDG&E Territory

SDG&E	Size Class Mean kWh/yr	Population Mean kWh/yr	Primary Sample Mean kWh/yr
Established Accounts	Certainty	130,949,481	130,949,481
	Large	11,162,222	11,162,222
	Medium	2,068,513	2,068,513
	Small	476,676	476,303
	Very Small	37,825	40,749
Young Accounts	Certainty	24,168,605	24,168,605
	Large	2,252,339	2,252,339
	Small	83,621	83,621

Exhibit 4-20 in a later section shows target numbers of completed on-site surveys for all three utility service territories. To achieve those targets for the SDG&E territory, Aspen randomly selected within stratum to create a sample of 591 observations. Please note that during the preparation for recruiting (directory assistance lookup, mailing of announcement, etc.), certain incidences of out-of-scope or misclassified status were detected and corrected. Therefore, population counts by stratum or in total may vary slightly between Exhibit 4-16 and Exhibit 4-20.

Phase 2 PG&E Territory Sampling

PG&E provided a file containing billing information from March 2001 through March 2002 for 22,165 accounts classified by SIC codes 21–34, 37–99. Only accounts still active in January 2002 or later were included, with the resulting data set having 22,004 records.

Exhibit 4-18 shows the resulting population frame means from the stratification scheme described in the introduction to this section. As can be seen, the stratum CVs are much lower than the overall CV, suggesting that variance reduction in estimates is highly likely if establishments vary in energy-efficiency behavior depending on size.

Exhibit 4-18. Phase 2 Sampling Frame Statistics for PG&E Territory

	Size Class	N	Mean Consumption[4]	CV
Established Accounts	Certainty	13	146,862,979	64
	Large	45	28,869,393	44
	Medium	270	6,038,463	52
	Small	644	1,122,930	46
	Very Small	6,273	65,815	146
Subtotal		7,245	824,672	461
Young Accounts	Certainty	9	6,201,360	99
	Large	21	328,990	65
	Small	117	24,584	95
Subtotal		147	446,241	943
Area Subtotal		7,392	817,147	943

Exhibit 4-19 shows the population and sample consumption means by stratum for the PG&E territory.

Exhibit 4-19. Phase 2 Population and Sample Consumption Means by Stratum for PG&E Territory

	Size Class Mean kWh/yr	Population Mean kWh/yr	Primary Sample Mean kWh/yr
Established Accounts	Certainty	146,862,979	146,862,979
	Large	28,869,393	28,869,393
	Medium	6,038,463	5,965,308
	Small	1,122,930	1,156,207
	Very Small	65,815	73,088
Young Accounts	Certainty	6,201,360	6,201,360
	Large	328,990	328,990
	Small	24,584	24,584

Exhibit 4-20 in a later section shows target numbers of completed on-site surveys for all three utility service territories. If the population count was less than the size of the desired draw in a cell, all available accounts were selected into the primary sample, and those cells were not represented in the secondary sample. Please note that during the preparation for recruiting (directory assistance lookup, mailing of announcement, etc.), certain incidences of out-of-scope or misclassified status were detected and corrected. Therefore, population counts by stratum or in total may vary slightly between Exhibit 4-18 and Exhibit 4-20.

Phase 2 Target Number of On-Site Interviews

The number of on-site interviews was reduced by 26 to a final target of 324 in exchange for providing incentives to potential respondents for participation. Exhibit 4-20 shows the Phase 2 target numbers of on-site surveys by stratum for all participating utilities.

Exhibit 4-20. Phase 2 Sampling and Target Numbers of On-Site Surveys, All Utilities

	Size Class	N	Target Onsites	Number Drawn for Recruiting
PG&E				
Established Accounts	Certainty	13	13	13
	Large	45	14	45
	Medium	270	20	140
	Small	644	20	155
	Very Small	6,273	20	156
Subtotal		7,245	87	509
Young Accounts	Certainty	1	1	1
	Large	5	5	5
	Small	141	20	141
Subtotal		147	26	147
Area Subtotal		7,392	113	656
SCE				
Established Accounts	Certainty	15	15	15
	Large	120	24	77
	Medium	541	19	143
	Small	1,579	19	150
	Very Small	13,275	19	150
Subtotal		15,530	96	535
Young Accounts	Certainty	1	1	1
	Large	148	19	147
	Small	463	19	146
Subtotal		612	39	294
Area Subtotal		16,142	135	829
SDG&E				
Established Accounts	Certainty	2	2	2
	Large	22	12	22
	Medium	112	12	112
	Small	307	12	150
	Very Small	2,763	12	150
Subtotal		3,206	50	436
Young Accounts	Certainty	4	4	4
	Large	21	10	21
	Small	130	12	130
Subtotal		155	26	155
Area Subtotal		3,361	76	591
Grand Total		26,895	324	2,076

4.2.2.3 On-Site Data Collection Instruments

While developing the industrial on-site questionnaire, Aspen conducted 28 interviews with suppliers of and experts on technologies covered in the questionnaire. The full report on findings from the surveys is provided in Appendix E. The results suggested a few items relevant to the questionnaire development, including process overhaul and the used-motor market.

None of the interviewed technology suppliers and experts was able to identify particular industries or processes that represent particularly attractive energy-efficiency opportunities. Although, they were able to identify energy-intensive industries. The interviewees predicted that results would indicate that energy plays only a minute role in decisions regarding process overhaul, except in the case of fuel-source decisions, and that data allowing meaningful quantitative analysis would not be obtained. Thus, in consultation with CEC, the questions regarding process overhaul were eliminated from the questionnaire.

Other changes to the questionnaire were minor. After attending a meeting on energy concerns in Southern California, the CEC contract manager requested that certain material be added to the questionnaire. This material included questions on corporate structure, budget cuts, and the relationship between technology decision-makers and payers for energy.

Although the questionnaire was approved, Aspen had not yet received utility billing files for population-frame creation. Therefore, for the pre-test, Aspen purchased a frame from *InfoUSA* containing contact data for all establishments in California classified in SICs 20, 35, and 36. Aspen selected and surveyed establishments with the highest revenues within each SIC. The population was also stratified based on geography, revenues, and SIC, and random samples from within each stratum were selected. Aspen then pre-tested the questionnaire on 23 of the selected establishments and found no major problems. Minor revisions were made, and the Industry Energy End-User Survey questionnaire was submitted for approval for large-scale implementation. The final Phase 1 questionnaire is provided in Appendix A.

In Phase 2, utility representatives requested that questions on additional technologies be added to the questionnaire. Accordingly, Aspen added sections on fluid process pumping and gas process heating, as well as questions pertaining to lighting. Because Phase I findings indicated that the length of the questionnaire was extensive and respondents were unlikely to respond positively to a longer survey, Aspen, in consultation with CEC and utility representatives, eliminated some material that appeared in Phase 1. Aspen pre-tested the Phase 2 survey and made minor changes. The Phase 2 Industry Energy End-User Survey questionnaire is provided in Appendix B.

4.2.2.4 Recruiting

In consultation with CEC, Aspen developed a telephone strategy for identifying respondents qualified to provide answers for the survey, which would be completed via on-site interviews.

Because not everyone asked to complete a two-hour survey will be willing to do so, Aspen anticipated having to contact thousands of establishments and make tens of thousands of telephone calls to complete the necessary amount of questionnaires.

The pre-test of the on-site survey suggested that incentives for participation might increase participation. Aspen and CEC decided that in return for participation, Aspen would offer Phase I participants:

- Custom benchmarking analysis that provided the establishment with a status check of how it was doing energy-wise compared to the average of other firms in its industry nationwide.
- Limited telephone consulting on energy efficiency by expert engineers.
- A floppy diskette containing a *Self-Assessment Workbook*, an *Industrial Productivity Training Manual*, and Web site addresses for other energy-efficiency resource tools that are available free of cost on the Web[5].
- A copy of the establishment's filled-out questionnaire.
- A copy of the final report that summarizes the findings of the study.

For Phase 2 incentives, the *Self-Assessment Workbook*, *Industrial Productivity Training Manual*, and Web site addresses for other energy-efficiency resource tools were replaced by software designed to help the respondents improve the efficiency of compressed-air and steam systems, motors, and pumps.

Aspen discussed with the CEC contract manager the advantages and disadvantages of offering the incentives, including the possibilities that establishments especially interested in energy-efficiency were more likely than others to be lured by the incentives and that efficiency-related incentives might change the behavior being studied. The issue was discussed again at the February 22, 2002 CALMAC meeting. The following points were agreed upon:

- The decision that reduction in non-response bias was worth risking changing behavior
- The act of surveying the respondents in and of itself was a potential source of change in respondents' behavior
- The decision that the tracking study should be viewed as tracking changes from many sources, including the actions of and incentives provided by the study itself

The utility representatives expressed the opinion that any changes in behavior resulting from giving out manuals were likely to be small.

Data Collection Instruments

For the pre-test of the telephone surveying/recruiting, Williams-Wallace Management Consultants (WWMC), a subcontractor to Aspen, used a pen-and-paper-based telephone surveying system designed to:

- Identify a respondent qualified to answer questions about industrial process at the facility contacted
- Verify that the establishment was in an in-scope SIC
- Determine if the facility had a water recovery and reuse system

For the large-scale implementation, Aspen programmed the telephone surveying and recruiting script into its computer-aided telephone interviewing (CATI) system. CATI provides many advantages, including immediate electronic data capture, facilitation of scheduling call-backs at the respondents' convenience, automation of skip patterns in the questioning, and continuous enforcement of stratum recruiting limits. Although following the CATI script on paper can be challenging, the computerized version is easy to use. The system automatically jumps to the appropriate screens as the telephone surveyor enters data.

The pre-test of the on-site survey suggested difficulty in acquiring reasonable numbers of completed surveys containing data on certain technologies in the on-site questionnaire. Therefore, questions about the presence of relatively rare technologies were added. In Phase 1, additional questions included:

- The number of motors bought in the last three years
- Whether electronic process controls were used to automatically unload or turn off equipment when not in use
- Whether the establishment had a power generation plant providing electricity for regular use
- Whether the facility had refrigeration systems totaling 20 horsepower or more for process cooling or food storage

Fears about not achieving adequate representation of these relatively rare technologies were unwarranted. Adequate representation to calculate summary statistics aggregated over the three in-scope SIC codes and the three participating utility service territories were achieved. The standard errors of estimates aggregated over utilities and SIC codes are generally low.

In Phase 2, questions were again asked that allowed Aspen to target technologies if necessary. For Phase 2, telephone survey questions on refrigeration and power generation were replaced with questions to determine if the facility had:

- Non-backup pumps totaling at least 50 horsepower
- A boiler system to provide steam and/or hot water

The final Phase 1 telephone recruiting survey instrument is provided in Appendix G. The Phase 2 version, containing explanations used in training new telephone surveyors, is provided in Appendix H.

Operations

Introductory Mailing. Aspen's experience is that introductory mailings increase the number of participants in on-site surveys. To enhance the effectiveness of the letter, Aspen drafted an introductory letter for approval and signature by the chairman of the CEC. CEC staff asked Aspen to seek the endorsement of the survey by the California Chamber of Commerce (CCC) and the California Manufacturers and Technology Association (CMTA). Both CCC and CMTA endorsed the study, and Aspen indicated their endorsements in the introductory letter. Aspen scanned CEC Chairman Keese's signature, applied it to the letters, and arranged for the letters to be mailed in waves by the CEC, ensuring that e letter had a CEC postmark.

To reduce the potential for sample selection bias, Aspen mailed letters and made subsequent telephone calls in waves. This procedure arguably made over-sampling easy-to-reach respondents less likely.

Telephone Surveying/Recruiting. Prior to calling sampled establishments, Aspen trained telephone surveyors/recruiters. The training included:

- An explanation of the purpose of the survey
- Instructions on how to handle frequently asked questions
- An explanation of the incentives for participation in an on-site survey
- Mock telephone surveys

Aspen screened telephone surveyors during training for clarity of speech and proper English.

Surveyors called participants weekdays from 9 a.m. to 5 p.m. California time. Telephone calls began about five days after the introductory letters were mailed. To allow for attrition between respondent recruitment and on-site survey completion, Aspen programmed the CATI system with stratum recruiting limits somewhat higher than the target number of completed onsites.

Telephone surveyors made up to 30 calls over many months to individual firms in strata whose recruiting goals turned out to be difficult to achieve. Only a few messages were left with each firm to reduce the chance of annoying potential respondents.

The data captured on the technology questions for Phases 1 and 2 are housed in the Confidential Database. This data includes:

- Numbers of calls per site
- Data on whether the establishment seemed correctly classified in the utility billing file
- Whether the establishment had moved
- Whether a qualified respondent was reachable
- The questions on technologies outlined earlier

Exhibit 4-21 shows the number of sample observations drawn for attempted recruiting and the number of establishments actually recruited by stratum for Phase 1.

Exhibit 4-21. Phase 1 Recruiting Statistics

Area / SIC	Size Class	N	Original Target Onsites	Number Drawn for Recruiting	Recruited
PG&E					
20	Certainty	2	2	2	2
	Large	29	13	29	12
	Medium	84	15	72	21
	Small	257	16	72	20
	Very Small	1,397	17	72	18
Subtotal		**1,769**	**63**	**247**	**73**
35	Certainty	2	2	2	0
	Large	19	13	19	7
	Medium	76	15	72	10
	Small	236	16	72	20
	Very Small	**2,078**	**16**	**72**	**12**
Subtotal		**2,411**	**62**	**237**	**49**
36	Certainty	4	4	4	1
	Large	22	13	22	9
	Medium	113	15	72	15
	Small	180	16	72	17
	Very Small	643	16	108	15
Subtotal		**962**	**64**	**278**	**57**
Area Subtotal		***5,142***	***189***	***762***	***179***
SCE					
20	Certainty	7	7	7	4
	Very Large	28	8	28	11
	Large	97	8	72	12
	Medium	122	8	72	11
	Small	692	8	72	10
Subtotal		**946**	**39**	**251**	**48**
35	Certainty	7	7	7	2
	Very Large	28	8	28	10
	Large	144	8	72	10
	Medium	475	8	72	10
	Small	3,304	8	72	10
Subtotal		**3,958**	**39**	**251**	**42**
36	Certainty	7	7	7	5
	Very Large	28	8	28	7
	Large	80	8	72	10
	Medium	204	8	72	11
	Small	363	6	25	7
	Very Small	742	5	47	7
Subtotal		**1,424**	**42**	**251**	**47**
Area Subtotal		***6,328***	***120***	***753***	***137***
SDG&E					
20	Certainty	2	2	2	1
	Large	15	4	15	5
	Medium	21	4	21	6
	Small	106	4	54	7
Subtotal		**144**	**14**	**92**	**19**
35	Certainty	2	1	2	2
	Large	17	4	17	5
	Medium	83	4	72	8
	Small	560	4	54	10
Subtotal		**662**	**13**	**145**	**25**
36	Certainty	3	2	3	2
	Large	17	4	17	5
	Medium	60	4	60	8
	Small	377	4	54	9
Subtotal		**457**	**14**	**134**	**24**
Area Subtotal		***1,263***	***41***	***371***	***68***
Grand Total		**12,733**	**350**	**1,886**	**384**

Exhibit 4-22 shows the number of establishments recruited by stratum in Phase 2.

Exhibit 4-22. Phase 2 Recruiting Statistics

	Size Class	N	Original Target Onsites	Number Drawn for Recruiting	Recruited
PG&E					
Established Accounts	Certainty	13	13	13	4
	Large	45	14	45	19
	Medium	270	20	140	33
	Small	644	20	155	33
	Very Small	6,273	20	156	25
Subtotal		7,245	87	509	114
Young Accounts	Certainty	1	1	1	1
	Large	5	5	5	1
	Small	141	20	141	15
Subtotal		147	26	147	17
Area Subtotal		7,392	113	656	131
SCE					
Established Accounts	Certainty	15	15	15	10
	Large	120	24	77	36
	Medium	541	19	143	32
	Small	1,579	19	150	32
	Very Small	13,275	19	150	30
Subtotal		15,530	96	535	140
Young Accounts	Certainty	1	1	1	1
	Large	148	19	147	24
	Small	463	19	146	23
Subtotal		612	39	294	48
Area Subtotal		16,142	135	829	188
SDG&E					
Established Accounts	Certainty	2	2	2	1
	Large	22	12	22	6
	Medium	112	12	112	27
	Small	307	12	150	27
	Very Small	2,763	12	150	17
Subtotal		3,206	50	436	78
Young Accounts	Certainty	4	4	4	1
	Large	21	10	21	5
	Small	130	12	130	8
Subtotal		155	26	155	14
Area Subtotal		3,361	76	591	92
Grand Total		26,895	324	2,076	411

4.2.2.5 On-Site Survey Field Operations

After recruiting establishments, Aspen examined them to ensure they fell within targeted SIC categories and were located at the addresses originally sampled. Establishments verified as in-scope were assigned to either an Aspen field surveyor or subcontractor. Two consultants employed by subcontractors Williams-Wallace Management Consultants and Robert Thomas Brown Company worked with Aspen to complete the target numbers of Phase 1 and Phase 2 surveys.

Training

All on-site surveyors used for the industrial survey had previous engineering or technical experience. Aspen provided each field surveyor with at least 2.5 days of training, including classroom instruction on general interviewing techniques and on the survey itself. The trainer conducted at least one survey on a recruited site while the trainees observed. The trainees conducted mock surveys and, in some cases, real surveys in the presence of the trainer. After the practice surveys, the trainer debriefed each trainee. Each trainee visited at least four sites with the trainer. Practice sites were selected representing the diverse size and purpose of the manufacturing sites to be surveyed.

Scheduling and Preparing for Surveys

Aspen surveyors scheduled their own surveys. One subcontractor used a central scheduler for all surveyors to keep them active in the field. After an increase in security concerns following the tragedy of September 11, 2001, Aspen sent a follow-up letter to recruited sites on company letterhead identifying their surveyor. The letter also reminded the respondent of the incentives offered for participation and requested that the respondent have available materials that would speed up the survey. These materials included:

- Maintenance logs
- Equipment cost information
- One recent month's electric and gas bills
- A numbered list of the new, replacement, and rewound motors bought in the last three years that are at least 1 horsepower and less than 50 horsepower in size
- A similar list of the motors 50 horsepower or larger

On-Site Survey and Numbers of Surveys Completed

Exhibit 4-23 shows the number of on-site surveys Aspen conducted in Phase 1. As discussed previously, the target number decreased after the sampling was conducted and during the surveying. The Phase 1 final target number of surveys was 236.

Exhibit 4-23. Phase 1—Number of Sites Completing On-Site Survey

	Size Class	N	Number Drawn for Recruiting	Revised Target On-Site Surveys	Surveyed
PG&E					
20	Certainty	2	2	2	1
	Large	29	29	7	7
	Medium	84	72	7	8
	Small	257	72	7	12
	Very Small	1,397	72	7	8
Subtotal		1,769	247	30	36
35	Certainty	2	2	2	0
	Large	19	19	6	5
	Medium	76	72	6	8
	Small	236	72	7	12
	Very Small	2,078	72	7	8
Subtotal		2,411	237	28	33
36	Certainty	4	4	4	1
	Large	22	22	6	5
	Medium	113	72	6	5
	Small	180	72	6	8
	Very Small	643	108	6	8
Subtotal		962	278	28	27
Undetermined		0	0	2	2
Area Subtotal		5,142	762	88	98
SCE					
20	Certainty	7	7	7	3
	Very Large	28	28	6	8
	Large	97	72	6	8
	Medium	122	72	6	6
	Small	692	72	6	5
Subtotal		946	251	31	30
35	Certainty	7	7	7	1
	Very Large	28	28	6	6
	Large	144	72	6	7
	Medium	475	72	6	8
	Small	3,304	72	6	6
Subtotal		3,958	251	31	28
36	Certainty	7	7	7	5
	Very Large	28	28	6	6
	Large	80	72	6	7
	Medium	204	72	6	6
	Small	363	25	4	4
	Very Small	742	47	4	3
Subtotal		1,424	251	33	31
Anaheim Territory		0	0	8	6
Area Subtotal		6,328	753	103	95
SDG&E					
20	Certainty	2	2	2	1
	Large	15	15	4	4
	Medium	21	21	4	4
	Small	106	54	4	5
Subtotal		144	92	14	14
35	Certainty	2	2	2	0
	Large	17	17	4	4
	Medium	83	72	4	4
	Small	560	54	5	6
Subtotal		662	163	15	14
36	Certainty	3	3	3	2
	Large	17	17	4	4
	Medium	60	60	4	4
	Small	377	54	5	5
Subtotal		457	134	16	15
Area Subtotal		1,263	443	45	43
Grand Total		**12,733**	**1,886**	**236**	**236**

Exhibit 4-24 shows the number of on-site surveys Aspen conducted in Phase 2.

Exhibit 4-24. Phase 2—Number of Sites Completing On-Site Survey

	Size Class	N	Number Drawn for Recruiting	Target On-Site Surveys	Surveyed
PG&E					
Established Accounts	Certainty	13	13	13	4
	Large	45	45	14	15
	Medium	270	140	20	26
	Small	644	155	20	29
	Very Small	6,273	156	20	20
Subtotal		7,245	509	87	94
Young Accounts	Certainty	1	1	1	1
	Large	5	5	5	1
	Small	141	141	20	13
Subtotal		147	147	26	15
Area Subtotal		7,392	656	113	109
SCE					
Established Accounts	Certainty	15	15	15	9
	Large	120	77	24	30
	Medium	541	143	19	27
	Small	1,579	150	19	25
	Very Small	13,275	150	19	23
Subtotal		15,530	535	96	114
Young Accounts	Certainty	1	1	1	1
	Large	148	147	19	20
	Small	463	146	19	14
Subtotal		612	294	39	35
Area Subtotal		16,142	829	135	149
SDG&E					
Established Accounts	Certainty	2	2	2	1
	Large	22	22	12	6
	Medium	112	112	12	20
	Small	307	150	12	19
	Very Small	2,763	150	12	12
Subtotal		3,206	436	50	58
Young Accounts	Certainty	4	4	4	0
	Large	21	21	10	5
	Small	130	130	12	5
Subtotal		155	155	26	10
Area Subtotal		3,361	591	76	68
Grand Total		26,895	2,076	324	326

Data Entry and Quality Control

Aspen incorporated several quality control (QC) procedures into the research plan to ensure that data reported in the Public Database and Confidential Database are accurate. These QC procedures involved the following actions.

Steps 2 through 8 are sometimes referred to by the generic term “data cleaning.” The following paragraphs provide further detail concerning each of the eight steps.

Thorough Training of Field Survey Staff. Aspen prepared a training manual for the 2.5-day training session that was conducted by an Aspen senior engineering staff member. The first day discussed the project’s requirements, specifically as they relate to: 1) protocols and techniques for contacting the assigned plants and scheduling an appointment; 2) customer relations, dress code, and conduct “dos and don’ts”; 3) a detailed, question-by-question review of the questionnaire; 4) descriptions of the technologies associated with each group of questions; 5) instructions concerning how to probe to obtain meaningful and accurate data and answers to questions; and 6) instructions for conducting self-checks and submitting completed survey forms.

The second day consisted of on-site application of the material covered during the first day. The instructor and the field staff visited two or three of the recruited sample sites. The instructor made prior arrangements for these visits. At each site, the field staff contacted the site representative and completed the survey form, under the direct supervision of the training instructor.

Self-Checking by Field Survey Staff. Field staff were trained to perform a “self-check” review of the completed survey forms, either in the building lobby or parking lot prior to leaving the plant. If any information had been inadvertently omitted, they attempted to immediately remedy the problem.

Initial Review of Completed Survey Questionnaires; Correction of Deficiencies. When completed survey forms were received at Aspen, they were logged and given a brief completeness check. If the survey was incomplete, the field surveyor was immediately contacted and asked to provide any missing administrative items, such as date of visit or name of person contacted, or to contact the participant and obtain missing data.

Rigorous Automated Item-by-Item Checking During Data Entry. The data entry process provided an excellent opportunity to apply automated QC routines to ensure data are valid. These routines ensure: 1) completeness (all required data are present); 2) the data element entered is the correct type (text or numeric); and 3) if numeric, the data value falls within an allowable range (which may be a function of other data values previously entered from the same survey form). Aspen programmed QC checks for almost every field in the database. Additional information concerning the automated checking routines is provided in Section 6.4 and Appendices I and J.

If entered data did not conform to specifications, the program alerted data entry personnel of the problem. If personnel elected not to change the data entry but instead proceeded to the next entry screen (which would be the case if the computer entry was identical to the entry recorded in the survey form), an exception report was generated by the software to flag problematic data for subsequent manual review and investigation by the data QC supervisor.

Initially, Aspen set the specified allowable range within relatively narrow limits, knowing this would generate many exception reports not representing true errors. However, Aspen wanted to ensure that all true errors were caught. Subsequently, after gaining experience from entering several dozen survey forms, Aspen modified some of the limits. More than half the “errors” flagged were not true errors, indicating that virtually all questionable data had been flagged.

QC Review and Resolution of Items Appearing on the Exception Reports. The data QC supervisor determined if the data anomaly should be referred back to the surveyor for correction or clarification or be accepted because it was a “false positive” indication of an error. After the supervisor completed the review, the corrected values were entered into the database and the exception record was simultaneously updated. The QC checks were run again to ensure that all exceptions had been properly handled.

Aspen performed manual checking because the realm of possible combinations of data entries that could actually be correct is vast and programming to authoritatively determine the acceptability of all combinations of data is impossible. The data QC supervisor (a senior Aspen engineer), in conjunction with the surveyor, other highly experienced engineers, and statistical staff, spent over 500 hours manually checking and deciding how to handle data elements flagged in the exception reports. When necessary, calls were made by the surveyor or the supervisor to the plant contact to verify data and, when appropriate, obtain corrected values.

The project's quality assurance (QA) procedures specified that each individual involved in any step of the data-entry and verification process sign and date a Survey Form Control Sheet, acknowledging successful completion of each step.

Monitoring of Field Survey Staff Performance; Correction of Deficiencies. Aspen applied checks to data reported on individual survey forms. Once the database was populated with a significant number of entries for each surveyor, Aspen analyzed the relative performance of each member of the field survey staff. Four performance indicators were selected:

- Incidence of reporting, "No motors were purchased during the past three years"
- Incidence of reporting motor sample data when it was reported that motors had been purchased
- Incidence of reporting, "Method of controlling the modulating air compressor"
- Incidence of reporting the presence of each technology group (e.g., electronic process control, refrigeration system)

Aspen then compared the results with all surveys. When anomalous performance was observed, the types and sizes of the plants for which the surveyor had obtained data were checked to determine if they explain the anomalous performance finding. If they did not, the performance findings were discussed with the surveyor. The surveyor was asked to verify that the reported data were correct, and in some cases, to call the plant contact or to return to the plant to ensure that data had not been overlooked. Aspen took corrective action to ensure that appropriate care was taken in future survey visits.

Verification of SIC Codes. Aspen recognized that some of the SIC codes recorded in the billing files obtained from the utilities may be incorrect because the designation was incorrect when it was first recorded or because the facility was subsequently sold to a business in a different industry and the record was not updated. To detect and correct these errors, the survey form contained an entry of what product(s) were manufactured at the site. These entries were individually reviewed to determine if they corresponded to the product(s) associated with the SIC listed in the billing file. The data QC supervisor reviewed all discrepancies, and, when appropriate, approved the data and had it entered into the database.

Preliminary Data Analysis; Correction of Deficiencies. Aspen conducted preliminary data analysis to check if the results appeared to be reasonable based on results produced by other surveys and studies involving the manufacturing sector. One-way frequencies, and in some cases differences, between entered values or ratios of two entered values (e.g., $/hp for purchased motors) were also run to detect suspicious data values. When suspicious values were detected, Aspen reviewed the original survey forms to ensure that errors had not slipped past the other checks. When necessary, calls were made to the plant contact to verify data and, when appropriate, to obtain corrected values.

4.2.3 Estimation of Summary Statistics

This section is organized by questionnaire section. Each section contains a table that lists all calculated data attributes. For each data attribute, the relevant question number(s) are presented. For data attributes that required computation using engineering formulae or data from multiple answers, the derivation or procedure used to calculate the desired results is provided. The relevance to energy policy is briefly discussed for selected items.

Aspen weighted all reported statistics to the population frame totals. Using the electricity billing files by PG&E, SCE, and SDG&E, Aspen derived these frames. All calculations were programmed in SAS. Aspen derived weights by dividing the responding sample size by the population size by stratum. A relatively new SAS procedure, called SURVEYMEANS, generated the standard errors of the weighted means, sums, proportions, and ratios. Fields from the Confidential Database are referenced in some of the analysis by their database names. The attached database codebooks (Appendices J and K) document the database field names.

In the tables that follow, if a ratio is indicated, the sum corresponding to the numerator and the sum corresponding to the denominator are reported. However, if either the numerator or denominator value was missing for an observation, Aspen excluded that observation from the ratio calculation, but the sums corresponding to the numerator and denominator were based on all non-missing values for that variable. Thus, the ratio derived by dividing the reported total for the numerator by the reported total for the denominator will not necessarily match the reported ratio. The results of the analysis are contained in the Public Database.

4.2.3.1 General Section

Exhibit 4-25 shows Phase 1 and Phase 2 analysis conducted for data obtained from questions in survey.

Exhibit 4-25. Analysis Conducted for General Section

Data Attribute	Linked Technologies/ Behaviors	Phase 1 Question Number(s)	Phase 2 Question Number(s)	Notes on Analysis	Analysis
Market Pathways					
What department specifies equipment such as motors and compressors?		6	7		Proportions
Does the same department that specifies equipment pay for electric bills?		7	8		Proportions
Allow supervisors or lower level managers to approve purchases		NA	12		Proportion
Maximum department can spend on equipment without approval		8	12		Average
Decision Factors					
Chosen to not buy equipment because of economic reasons over last 3 years		NA	11	Question not in P1*	Proportions
Topics included in energy management training program		Maintenance 17, 18	14, 15		Proportions
Other Market Characterization Attributes					
Year the facility was built		3	2		Proportions
Have there been budget cuts in the last 2 years?		9	NA	Question not in P2	Proportions
What budget areas were cut		10	NA	Question not in P2	Proportions
Building square footage		NA	6	Question not in P1	Proportions
Has production increased or decreased over last 3 years?		NA	9	Question not in P1	Proportions
By how much has production increased or decreased over the last 3 years?		NA	9	Question not in P1	Average
Percentages of lighted floor space with T8 and T12 lamps	Lighting Technology	NA	10	Question not in P1	Average

*P1= Phase 1

P2 = Phase 2

Relevance of Selected Items to Energy Policy

Does the staff who specifies equipment also have fiscal responsibility for utility costs?
Phase 2, Questions 7 and 8
Relevance: One of the biggest barriers to incorporating energy-efficient technology is the lack of communication between the managers responsible for overhead expenses, such as utility bills, and the technical staff responsible for purchasing and operating the technology. Questions 7 and 8 help gauge the severity of this barrier.

T12 vs. T8 Lighting
Phase 2, Question 10
Relevance: T8 lighting is gradually replacing T12 lighting. This question measures the current extent of this transition. If the results draw interest, Aspen recommends more extensive data collection involving this technology.

4.2.3.2 Motors Section

This section begins with a discussion of premium-efficiency motor market share. Exhibit 4-26 provides the analysis conducted for the remainder of the Motor Section.

Motor Market Share

Two market shares (and associated segmentations by motor size, utility service territory, and SIC) were calculated using data in the Motors Section:

- Proportion of motor horsepower bought in the last three years that are premium efficiency
- Proportion of variable-flow-application motor horsepower controlled with VSDs

Traditionally, it is assumed that rewinding a motor is less efficient than buying a new replacement motor. Thus, the market share of new motors purchased versus the total market for purchased and rewound motors represents a third efficient-product market share. This is undoubtedly true when the old motor's rated efficiency is significantly less than the minimum rated efficiency for a new motor. However, interviews with expert suppliers show that the correlation between degraded efficiency and rewinding is not absolute in other situations. Rewound motors can be as efficient as or even more efficient than the original motor if certain rewind practices are followed. For those that presume replacement is more efficient than rewinding, the data available in the database can be used to make that point.

Premium-Efficiency Motor Market Share
This market share is defined as the motor horsepower bought in the last three years that meet the minimum standards to be labeled as "premium efficiency," compared to all motor horsepower purchased in the last three years. The standard for premium efficiency used here was established by NEMA. To estimate premium-efficiency motor market shares, it must first be determined if data collected from a motor nameplate qualifies the motor as "standard" or "premium" efficiency. This is a procedure, rather than just an assembly of formulae, so it is presented here in the order of operations. The efficiency class of each inventoried motor is determined, and then

Exhibit 4-26. Analysis Conducted for Motors Section

Data Attribute	Linked Technologies or Sections	Phase 1 Question Number(s)	Phase 2 Question Number(s)	Analysis Notes	Analysis
Technology Shares, Costs, and Quantities					
Share of premium-efficiency motor sales overall and segmented by size (large vs. small)		25-27	6, 7, 23		Formula
Total motor sales overall and segmented by size (large vs. small) in last 3 years		5, 25-27	6, 7, 8, 23		Formula
Share of VSD controlled motor sales	VSDs	25-27	6, 7, 23		Formula
Total hp of VSDs for variable flow applications bought in last 3 years	VSDs	16	16		Formula
Price paid – by hp and efficiency		27	23		Average
Market Pathways					
Sources of new motors		6	8		Ratio of total for each segment
Who specifies motor attributes		20	19		Proportions
Motor supply channels		21	20		Proportions
Marketing channels		24	22	Extra choice in P2	Proportions
Used equipment sources		NA	24		Proportions
Indicators of Practices Relating to Energy Efficiency					
QC on rewound motors		12, 13	13	Q13 from P1 was not in P2	Proportions
Purchasing policies		1, 2	3, 4		Proportions
Decision Factors					
When rewind, reasons performed		8	10		Proportions
Satisfaction with VSD performance	VSDs	17	17		Proportions
VSD decision factors	VSDs	18, 19	17, 18		Proportions
How many bidders per purchase		22	NA		Average
Procurement time of premium efficient motors		23a	21a		Proportions
Installation cost of premium-efficient motors		23b	21b		Proportions
Maintenance cost of premium-efficient motors		23c	21c		Proportions
Other Market Characterization Attributes					
Meaning of “premium efficiency”		NA	1, 2		Proportions
Frequency of motor rewinding?		7, 9, 10	9, 11, 12		Proportions

the sample motors are weighted up to represent the entire motor horsepower bought in the last three years.

To estimate premium-efficiency motor market shares using the data from the random sample of motors, Aspen first determined if each motor in the sample was premium efficiency. This determination was based on the size of the motor, its enclosure, and its revolutions per minute (RPM). The details of this process are presented below.

Determining the minimum efficiency to qualify as premium efficiency. To determine motor size, Aspen used the OutputPower field (Motors, Question 27):

- First, when necessary, rated motor power in kilowatt is converted to rated motor horsepower:
  - If labeled "kW," Aspen converted to horsepower: hp = kW / 0.746
- Next, we converted rated motor horsepower to nominal horsepower for classification purposes. This is the only way to reflect the Code of Federal Regulations (CFR) specification.[6] This specification exists only for motors between 1 horsepower and 200 horsepower. Thus, only motors in this output power range were included in the calculation of efficiency market share.

If Rated Motor HP is	Nominal Motor Hp[7]
1 – 1.249	1
1.25 – 1.749	1.5
1.75 – 2.499	2
2.5 – 3.999	3
4 – 6.249	5
6.25 – 8.749	7.5
8.75 – 12.49	10
12.5 – 17.49	15
17.5 – 22.49	20
22.5 – 27.49	25
27.5 – 34.99	30
35 – 44.99	40
45 – 54.99	50
55 – 67.49	60
67.5 – 87.49	75
87.5 – 112.49	100
112.5 – 137.49	125
137.5 – 174.99	150
175 – 200	200

To determine nominal speed, Aspen used the RPM field in Motors, Question 27:

- If the RPM field was blank (and all other needed data were available), Aspen looked up the speed from the make and model number using MotorMaster. If no MotorMaster match was found, the motor was excluded from the remainder of the efficiency analysis.
- Aspen converted from rated motor RPM to nominal RPM using the following table:[8]

If Rated Motor RPM is	Nominal Motor RPM
1,100 – 1,200	1,200
1,700 – 1,800	1,800
3,400 – 3,600	3,600
All other	N.A. (Not governed by Standard)

To determine the enclosure type, Aspen used the Enclosure field in Motors, Question 27. However, if "Cannot be determined" was checked or if no box was checked, the motor was eliminated from the analysis.

Next, Aspen looked up the minimum efficiency (MinPremium) to be considered "premium-efficiency" for a motor of the specified power, RPM, and enclosure type, using the following table:[9]

Nominal Motor HP	Open Drip-Proof (ODP)			Totally Enclosed Fan Cooled (TEFC)		
	1,200 RPM	1,800 RPM	3,600 RPM	1,200 RPM	1,800 RPM	3,600 RPM
1	82.5	85.5	77	82.5	85.5	77
1.5	86.5	86.5	84	87.5	86.5	84
2	87.5	86.5	85.5	88.5	86.5	85.5
3	88.5	89.5	85.5	89.5	89.5	86.5
5	89.5	89.5	86.5	89.5	89.5	88.5
7.5	90.2	91	88.5	91	91.7	89.5
10	91.7	91.7	89.5	91	91.7	90.2
15	91.7	93	90.2	91.7	92.4	91
20	92.4	93	91	91.7	93	91
25	93	93.6	91.7	93	93.6	91.7
30	93.6	94.1	91.7	93	93.6	91.7
40	94.1	94.1	92.4	94.1	94.1	92.4
50	94.1	94.5	93	94.1	94.5	93
60	94.5	95	93.6	94.5	95	93.6
75	94.5	95	93.6	94.5	95.4	93.6
100	95	95.4	93.6	95	95.4	94.1
125	95	95.4	94.1	95	95.4	95
150	95.4	95.8	94.1	95.8	95.8	95
200	95.4	95.8	95	95.8	96.2	95.4

To determine the actual efficiency of each motor (MotorEff):

- If the efficiency field (in Motors, Question 27) was complete, Aspen used the entered value as motor efficiency.

- If efficiency was not recorded, but volts, phase, amps, and power factor were provided, Aspen used the following formulae for motor efficiency:

    - Motor efficiency = kW_out/kW_in, where:
        - kW_in = Volts * $(\text{Phase})^{0.5}$ * Amps * PowerFactor / 1000, and
        - kW_out = OutputPower * 0.746

- If not enough data were available, Aspen looked up the efficiency for the motor make and model number using MotorMaster.

- If all of this failed, the efficiency could not be determined with certainty, and “NA” was entered for efficiency.

Once all these steps were completed, Aspen compared the actual motor efficiency with the minimum efficiency for premium motors and created a flag to indicate if that motor was premium efficiency. If MotorEff was equal to or greater than MinPremium, then **Premium**=Yes. If it was less than MinPremium, then **Premium**=No. If either field was “NA” then efficiency classification for that motor could not be determined, and **Premium**=Unknown.

Aspen then created a flag that denoted each motor as being either less than 50 horsepower or at least 50 horsepower. (Flag50 = 0 if under 50, Flag50 = 1 if greater than or equal to 50.)

Next, Aspen counted the number of motors inventoried that were in each of the two size categories, considering only motors that have a “Yes” or “No” in the efficiency classification field and excluding those that do not have determined efficiency. These created variables are Hpover50count and Hpunder50count.

Then, Aspen estimated the proportion of total horsepower that was premium efficiency. For each surveyed site, we defined and calculated the following:

1. Premhpover50inv = Σ (hp for motors with Flag50 = 1 and Premium = “Yes”)
2. Premhpover50tot = Premover50inv * Over50HPBought / Hpover50count
3. Stdhpover50inv = Σ (hp for motors with Flag50 = 1 and Premium = “No”)
4. Stdhpover50tot = Stdover50inv * Over50HPBought / Hpover50count
5. Premhpunder50inv = Σ (hp for motors with Flag50 = 0 and Premium = “Yes”)
6. Premhpunder50tot = Premunder50inv * Less50HPBought / Hpunder50count
7. Stdhpunder50inv = Σ (hp for motors with Flag50 = 0 and Premium = “No”)
8. Stdhpunder50tot = Stdunder50inv * Less50HPBought / Hpunder50count
9. Premhptot = Premhpover50tot + Premhpunder50tot
10. Stdhptot = Stdhpover50tot + Stdhpunder50tot

Finally,

Premium Efficiency Motor Market Share = Σ ((Premhptot)$_n$)/ Σ (Premhptot + Stdhptot)$_n$

The estimated totals corresponding to the numerator and denominator are presented in the summary statistics tables, along with their estimated standard errors.

Aspen estimated this share for all motors 1–200 horsepower, as well as for the segments 1–49 horsepower and 50–200 horsepower.

Market Share – Variable Speed Drives in Use for Variable-Flow Applications
Using the data collected for the random sample of motors and limiting the sample to the motors indicated as being used in a variable-flow application, Aspen took the ratio of the horsepower of the motors for which a VSD was in use to the horsepower of the motors indicated as being used in a variable-flow application.

Relevance of Selected Items to Energy Policy

Motor Purchasing Practices
Phase 1, Questions 1 and 2 and Phase 2, Questions 3 and 4
Relevance: Indicators of motor purchasing practices, these questions help researchers understand the channels by which motors come to industrial plants and how premium-efficiency motor specifications are incorporated into purchases.

Understanding of the Significance of the Term "Premium Efficiency" with Regard to Motors
Phase 2, Questions 1 and 2
Relevance: These questions gauge the effectiveness of NEMA and energy-efficiency allies in conveying the idea that "premium-efficiency motor" has specific meaning and represents a value proposition to prospective buyers. The questions also help explain the meaning of the terminology to those who do not know it, which is important for meaningful answers to later questions.

Frequency of Motor Rewinding
Phase 1, Questions 7, 9, 10 and Phase 2, Questions 9, 11, and 12
Relevance: It is possible for a rewound motor to have the same or even higher efficiency as it had when purchased, but more often the result of rewinding is a lower efficiency. Since older motors in general have lower nameplate efficiencies than newer ones, rewinding also represents a lost opportunity to improve efficiency. These questions assess how often facilities staff rewound motors.

QC Requirements for Motor Rewinding Requirements
Phase 1, Questions 12 and 13 and Phase 2, Question 13
Relevance: Motor efficiency is affected by the quality of the motor rewinding. Responses to this question show levels of end-user awareness and insistence on practices that will result in higher efficiency motors after rewinding.

VSDs on Pumps and Fans
Phase 1, Questions 14 and 15 and Phase 2, Questions 14 and 15

Relevance: From the perspective of saving the maximum percentage of energy per application, many of the biggest opportunities for VSDs are for pumps and fans that control varying flow of liquids and gases (e.g., pumps and fans). These questions together measure the proportion of variable flow pumps and fans that are controlled by VSDs.

Non-Energy Benefits of Premium-Efficiency Motors
Phase 1, Question 23 and Phase 2, Question 21
Relevance: Energy efficiency purchase decisions are not based solely on energy cost savings. Marketing non-energy benefits can sway buyers that are "on the fence" or even be the primary basis for making a change that will save energy. Conversely, if the high-efficiency product is seen to have other drawbacks, then it can thwart a purchase. For example, older motors sometimes were overbuilt and heavier, and thus perceived to last longer than early generations of high-efficiency motors. This question collected data on if that perception remains prominent.

Marketing Resources
Phase 1, Question 24 and Phase 2, Question 22
Relevance: If energy efficiency advocates want to educate end-users directly, responses to this question will help channel efforts most appropriately.

Motor Inventory, Sampling, Premium-Efficiency Market Share
Phase 1, Questions 5, 25, 26, and 27 and Phase 2, Questions 6, 7, 8, and 23
Relevance: The data in this series of questions allow estimation of horsepower-weighted premium-efficiency motor market share based on a sample nameplate data collection from new motors at each site. Premium-efficiency motors are rated as such as a function of horsepower, revolutions per minute, and enclosure type. The inventory is only of motors bought and installed in the last three years. The year of manufacture field thus can be used to indicate frequency of purchase of used motors, either alone or as part of the purchase of used equipment that includes motors.

4.2.3.3 Process Fluid Pumping Systems Section

Exhibit 4-27 shows the analysis conducted on the Process Fluid Pumping Systems Section. Following the table is some discussion of relevance to energy policy. Results of the analysis are in the Public Database. Selected findings are discussed in Section 4.4.

Exhibit 4-27. Analysis Conducted for Process Fluid Pumping

Data Attribute	Linked Technologies/ Behaviors	Phase 2 Question Number(s)[10]	Notes on Analysis	Analysis
Technology Shares, Costs, and Quantities				
Facility uses pumps totaling at least 50 horsepower		1		Proportion
Total pumping horsepower for process pumping loads		2	If given as a range instead of exact number, use midpoint	Mean/Average
Indicators of Practices Relating to Energy Efficiency				
Number of pump impellers trimmed or pumps downsized in last 3 years		3		Proportion
Total pump horsepower that had impellers trimmed or pumps downsized in last 3 years		4		Proportion
Which of the following pumping system upgrades have been performed? In the last 3 years?		5		Proportions

Relevance of Selected Item to Energy Policy

Trimming Impellers

Phase 1, Questions 3 and 4

Relevance: Process system designers specify pumps that are capable of delivering at least the flow rate needed at design conditions. Because most pumps are not custom built for systems, often it is necessary to specify pumps slightly larger than ideal. The combination of over-sizing for such practical reasons, incorporating safety factors in hydraulic system design, and running systems at less than design conditions means that pumps often are oversized, even in applications where the flow rate does not vary. The standard approach is to install the pump, and then use a fixed throttle to reduce the flow rate to the desired gallons-per-minute. If substantial throttling is required and staff members are confident that requisite flow rates will not increase for the next few years, it is more efficient to trim the impeller in the pump than to adjust the throttle.

4.2.3.4 Compressed Air Section

Exhibit 4-28 shows the analysis conducted for the Compressed Air Section. Further analysis of data attributes and a discussion of the relevance of selected items also is provided.

Exhibit 4-28. Analysis Conducted for Compressed Air Section

Data Attribute	Linked Technologies/ Behaviors	Phase 1 Question Number	Phase 2 Question Number	Notes on Analysis	Analysis
Technology Shares, Costs, and Quantities					
Percentage of firms with compressors totaling >50 horsepower		1	1		Proportion
Total non-backup horsepower		2	2		Sum
Variable speed drives	VSDs	2	2		Ratio
Intermediate air flow controller		7	6		Proportions
Non-throttle part-load control, as percent of total horsepower		3	3		Formula
Optimal sequencing of multiple compressors		4	4		Proportions
Amount spent in last two years on compressed-air system efficiency		25	20	If "none" checked, set=0	Average
Heat recovery		2	NA		Ratio
Indicators of Practices Relating to Energy Efficiency					
Multiple distribution systems, with multiple pressure settings		6	5		Proportions
Proportion with excess discharge pressure		8, 9	7, 8	Question order reversed	Formula+ Distribution
Average decrease in discharge pressure if pressure was decreased in last 2 years		8, 11	7, 10		Formula
Percent of horsepower where discharge pressure reduced because of changes to distribution system		11, 12	10, 11		Ratio
Percent of firms that reduced discharge pressure because of process or tool changes		1, 12	1, 11		Proportion
Compressors draw air intake location		5	NA		Proportions
Added storage		17, 18	NA		Proportions
Converted electric to pneumatic, and vice versa		19, 21	15, 17		Ratio
Installed nozzles		23	19	Added choices in P2	Proportions
Frequency searching for air leaks	Maintenance	13	12		Proportions
Ultrasonic leak detector used	Maintenance	NA	13		Proportions
Leak audit done in last two years	Maintenance	16	14		Proportions
Services done to monitor efficiency	Maintenance	NA	22		Proportions
Market Pathways					
How become aware of new products		26	21	Added choices in P2	Proportions

*P1= Phase 1, P2 = Phase 2

Further Specification of Analysis

Technology Shares, Costs, and Quantities

- *Total non-backup horsepower for all air compressors (Phases 1 and 2 Question 2)*
  Total non-backup horsepower was calculated as total compressor motor horsepower for all inventoried air compressors where the typical operating condition was not indicated as "backup unit."

- *Percent of non-backup modulating compressor horsepower controlled by other than a throttle valve (Phases 1 and 2, Question 3)*
  The non-backup horsepower for modulating units in Phase 1, Question 2 (Phase 2, Question 2) was totaled for the establishments indicating anything other than "Throttle (or other variable inlet pressure device on screw compressors)" for part-load control in Phase 1, Question 3 (Phase 2, Question 2). This non-throttle part-load control horsepower was then taken as a percentage of the total non-backup horsepower for all modulating compressed-air units.

- *Variable speed drives (Phases 1 and 2, Question 2)*
  Numerator is total NonbackupHP for respondents that have VSDCtl=Yes at least one time in the Phase 1, Question 2 (Phase 2, Question 2) table; denominator is total NonbackupHP for all respondents.

- *Heat recovery (Phase 1, Question 2)*
  Calculate the percentage of total MotorHP in Phase 1 Q2 for which HeatRecovery =Yes. Numerator is NonbackupHP for compressors for which HeatRecovery=Yes; denominator is total NonbackupHP for all respondents.

Indicators of Practices Relating to Energy Efficiency

- *Electric equipment horsepower replaced by pneumatic equipment in last two years as a percentage of total non-backup compressor horsepower.*

  The estimated electric horsepower replaced by pneumatic equipment in the last two years (Phase 1, Question 19; Phase 2, Question 15) was totaled and taken as a percentage of total non-backup horsepower (Phase 1, Question 2; Phase 2, Question 2).

Electric End-Use HP Removed as a Percentage of Total Compressed Air HP
= Removed HP / Nonbackup HP

$$\text{Removed HP} = \Sigma\ [(\text{Removed HP})_n * (\text{Population Weight})_n\ ]$$

$$\text{NonbackupHP} = \sum ([\ \text{MotorHP, for all Phase 1Q2 (Phase 2 Q2) records where OperationCondition} \neq \text{“Backup Unit”})_n * (\text{Population Weight})_n\ ]$$

- *Electric equipment horsepower installed replacing pneumatic equipment in last two years as percentage of total non-backup compressor horsepower.*

  The estimated electric horsepower installed replacing pneumatic equipment in the last two years (Phase 1, Question 19; Phase 2, Question 15) was totaled and taken as a percentage of total non-backup horsepower (Phase 1 and Phase 2, Question 2).

  Electric End Use HP Added as a Percentage of Total Compressed Air HP
  = Added HP / Nonbackup HP

  Added HP = Σ [(Installed HP)$_n$ * (Population Weight)$_n$]

- *Average decrease in discharge pressure setting for motors that decreased discharge pressure in the last two years (Phase 1, Questions 8 and 11 and Phase 2, Questions 7 and 10).*

  Establishments that responded to Phase 1 Question 11 (Phase 2, Question 10) with "decreased pressure to the discharge pressure noted in Phase 1, Question 8 (Phase 2, Question 8)" were selected as the analysis population. Minimum compressor discharge pressure settings were derived from responses to Phase 1, Question 8 (Phase 2, Question 8). If only one minimum compressor discharge pressure setting was provided, it was selected as the minimum compressor discharge. But, if low and high minimum compressor discharge pressure settings were provided, the minimum compressor discharge pressure setting was defined as the average of the low and high values. The response to Question 11 (concerning having increased or decreased the discharge pressure in the last two years) was used to determine the pressure setting prior to the decrease. The minimum compressor discharge pressure setting in Phase 1, Question 8 (Phase 2, Question 8) was then subtracted from the pressure setting prior to the decrease to derive the decrease in discharge pressure. The weighted average decrease in discharge pressure setting and associated standard error can then be calculated.

- *Percentage of horsepower for which discharge pressure reduced because of changes to distribution system (Phase 1, Questions 11 and 12; Phase 2, Questions 10 and 11).*

  The non-backup horsepower for establishments that decreased the discharge pressure in the last two years (Phase 1, Question 11; Phase 2, Question 10) and indicated they were able to do so because they (Phase 1, Question 12; Phase 2, Question 11) 1): eliminated leaks; added a receiver; added, joined, or increased the diameter of distribution headers; added an intermediate flow controller; installed dryers or coolers with reduced pressure drop compared to previous; or other; was totaled for the numerator. Non-backup horsepower was used as the denominator.

- *Percentage of establishments that reduced discharge pressure because of process or tool changes in the last two years (Phase 1, Questions 1 and 12; Phase 2, Questions 1 and 11).*

The numerator was the estimated number of firms that reduced discharge pressure because of process or tool changes in the last two years. The denominator was the number of firms with 50 or more horsepower of non-backup compressor power.

Relevance of Selected Items to Energy Policy

Heat Recovery
Phase 1, Question 2
Relevance: Air gets hot as it is compressed. The compressed-air needs to be dried and in many cases cooled before it can be delivered to air-using equipment. The oil that is mixed with the air during compression likewise gets hot and needs to be cooled after separation from the air and before it is reintroduced to new air about to be compressed. The oil cooling in particular represents lost energy from the system. The extent that energy can be captured so that the energy from cooling is redirected represents an energy-efficient practice. Recovered heat can be used to reheat compressed dry air, offsetting compressor energy, or to heat water and off-set boiler energy. Heat recovery portion of Question 2 was dropped in Phase 2.

Part-Load Control
Phase 1, Question 3
Relevance: In compressed-air systems, the best practice is to run all compressors but one at full load, and to allow that one compressor to either modulate its output or cycle off and on to meet varying plant air needs. While no one type of part-load control is best for every compressor, it is true that using inlet-throttle or bypass-type part-load controls are particularly inefficient means of part-load control. Better alternatives are available.

Variable Speed Drives
Phase 1, Questions 2 and 3
Relevance: It is not unequivocally true, but for many customers using a VSD to modulate one compressor to meet air needs is a good approach to part-load control.

Automatic Sequencing Controls
Phase 1, Question 4
Relevance: Automatic sequencing controls mix and match the operation of compressors to minimize overall compressed-air plant energy use and, if desired, make sure that the designated "backup" unit(s) are rotated so all compressors get occasional use. Sequencing controls do not guarantee more efficient compressor plant operation, but it is more likely.

Source of Air
Phase 1, Question 5
Relevance: Cool air is denser than warm air. Air compression is the process of making air more dense. Therefore, it is less work for a compressor to draw in cool air to compress instead of warm air. Cool air is essentially slightly precompressed compared to warm air. Since compressor rooms typically are unconditioned and have a lot of waste heat (see the heat recovery discussion above), outside air is usually cooler than compressor room air. Even in hot arid regions, the compressor rooms tend to be hotter than outside. By ducting the compressor intake to outdoor air supply instead of the compressor room, less compression is required.

Multiple Distribution Systems

Phase 1, Question 6 and Phase 2, Question 5

Relevance: It requires more energy to compress air to a higher pressure than to a lower pressure. Typically, facility managers set their compressed-air system to deliver compressed air at the pressure required for the highest pressure end-use equipment, and use regulators to supply lower pressure elsewhere through the same distribution system to equipment that does not need high pressure air. When practical, running two separate systems with one at a lower pressure can save energy because it avoids over-compressing and then decompressing air. Answers to this question may indicate good compressed-air management practices.

Intermediate Air Flow Controller

Phase 1, Question 7 and Phase 2, Question 6

Relevance: These devices are reported to save energy. Their presence in a system undoubtedly indicates that the compressed-air system is or has been subject to careful evaluation of energy needs, and thus is an indirect indicator of attention to compressed-air system energy use.

Excess Discharge Pressure

Phase 1, Questions 8 and 9; Phase 2, Questions 7 and 8

Relevance: The minimum discharge pressure at the compressor is always as high or higher than the pressure required by downstream pneumatic equipment. Well-designed and maintained systems with adequate air storage typically have a pressure drop from discharge to end-use of 10 pounds per square inch (psi) or less. If the pressure drop is substantially higher, this is an indication of a system that is not operating as efficiently as possible. To give an indication regarding the establishment's conditions using these two parameters, Aspen created a distribution from the answers to compressed air Question 8 and Question 9 (for Phase 1; Question 7 and Question 8 for Phase 2).

PressureDrop = MinPressureRange_low (Question 8) – MaxPressureRange_high (Phase 1 Question 9; Phase 2 Question 8)

Then, Aspen generated a distribution in 5-psi increments for the variable PressureDrop.

Reducing Pressure

Phase 1, Questions 11 and 12 and Phase 2, Questions 10 and 11

Relevance: Reducing the pressure saves energy as explained above.

Leak Audits

Phase 1, Questions 13 and 16 and Phase 2, Questions 12–14

Relevance: Leaks occur regularly, and eliminating them saves energy. Using an ultrasonic leak detector helps locate leaks.

Storage Receivers
Phase 1, Questions 17 and 18
Relevance: Compressors that cycle between loaded and unloaded states are generally efficient. However, there are some energy losses that occur with every cycle, so it saves energy to minimize the number of load-unload cycles that occur per hour. Adding compressed-air storage capacity is the best way to do this.

Pneumatic-to-Electric Equipment and Vice Versa
Phase 1, Questions 19, 21 and Phase 2, Questions 15, 17
Relevance: There are many applications for which compressed-air equipment is the only option, or for which such equipment is more productive than the electricity-using equivalent. There also are applications where either a pneumatic or electric tool will work equally well. In such instances, the electric tool typically requires from 1/3 to 1/20 of the electricity as the pneumatic tool, after accounting for the energy required of the compressed-air plant. These questions are direct indicators of changes that increase or decrease energy use.

Good reasons exist to choose pneumatic tools when functionally equivalent electric tools are an option, but electrical energy efficiency is not one of them. If an electric drill requires 500 Watts to drive a drill bit through wood, an equally powerful pneumatic drill will require a compressor to increase its load by 1,000 to 10,000 Watts of electric power to do the same job. The exact "exchange rate" varies depending on the compressed-air distribution system, part-loading, leaks, compressor efficiency, turbine and motor efficiencies, and a host of other factors, but the bottom line is that pneumatic tools use more electricity. The compressed-air demand increase or savings was not estimated in this study because it required such a gross assumption. If it were to be estimated, it would be on the exchange rate of 4 to 5 compressor horsepower per end-use horsepower.

Aspen asked plant managers if they had converted any electric equipment to pneumatic or vice versa. To normalize the results, the horsepower increase or decrease was expressed as a percentage of total non-backup compressor power.

Air Nozzles
Phase 1, Question 23 and Phase 2, Question 19
Relevance: Nozzles use far less air than open hoses to blast the same velocity of air, and thus save energy.

4.2.3.5 Maintenance Practices Section

Exhibit 4-29 shows the analysis conducted for the Maintenance Practices Section.

Exhibit 4-29. Analysis Conducted for Maintenance Practices Section

Data Attribute	Linked Technologies/ Behaviors	Phase 1 Question Number(s)	Phase 2 Question Number(s)	Notes on Analysis	Analysis
Percentage of firms with auto-lubrication systems		9	8		Proportion
Total horsepower of blowers and fans	Blowers	8	7		Sum
Total horsepower of auto-lubricated motors	Electric motors	10	9		Sum
	Electric motors	1	1		Proportion
	Blowers	1	1		Proportion
	Compressed Air	1	1		Proportion
Belt replacement procedure	Maintenance	6	NA	Question not in P2*	Proportion
	Electric Motors	15	13		Proportion
	Compressed Air	15	13		Proportion
	Refrigeration	15	13		Proportion
	Lighting	15	13		Proportion
	Electric Motors	NA	13	Question not in P1	Proportion
How become aware of new products		NA	14	Question not in P1	Proportion
Received energy training		17, 18	General Section 14, 15	Question not in P2	Proportion
Why decided to use auto-lubrication		11	10		Proportion
Who makes maintenance policy decisions		7	6		Proportion
Over the past two years … or stayed the same?		4	4		Proportion
Realized benefits of auto-lubrication		14	12		Proportion
Interest in information on the effects of maintenance on energy use		19	NA		Proportion
Interest in information on the effects of maintenance on equipment reliability		20	NA		Proportion

*P1= Phase 1, P2 = Phase 2

Relevance of Selected Items to Energy Policy

Maintenance Policies for Specific Equipment Types

Phase 1 and Phase 2, Question 1

Relevance: Well-maintained equipment runs more efficiently and reliably. These questions measure the extent to which facility managers invest in routine preventive maintenance to minimize energy costs.

Belt Replacement Procedure
Phase 1, Question 6
Relevance: Designers of systems with large motors and belt-driven equipment typically specify pulley systems with multiple parallel belts to reduce the strain on a single belt. Strain causes stretching, and once a belt stretches it may begin to slip. Slippage generates friction, thereby wasting energy. Belts slip the least when they all are exactly the same length. All belts stretch with extended use, so when one breaks or gets substantially longer than others, the most efficient policy is to replace them all at once. It also may save labor and productivity dollars. All-new belt sets are more likely to be close to the same length then a mixture of new and old belts, but they are not exactly the same even when new. To maximize efficiency, manufacturers often sell new belts in matched sets to reduce variations in length.

The bottom line is that replacing all belts with a matched set is the most efficient practice, replacing them all without matched sets is next best, and replacing only the broken belts is the least-desirable practice.

Use of Blowers
Phase 1, Question 8; Phase 2, Question 7
Relevance: Many items of equipment in industrial facilities require pressurized air between 1 pounds per square inch gauge (psig) and 20 psig, a higher pressure than fans can deliver. A common way to get this pressurized air is to tap into the (nominally 110 psig) plant air line, and use a pressure regulator to reduce the pressure to the desired level, such as 10 psig. This practice is inefficient because more work is required to compress air to 110 psig and then depressurize it to 10 psig, than to just compress it to 10 psig.

For this survey, blowers were considered to be devices that provide pressurized air in the 1- to 20-psig range. Their presence was an indicator of good facilities energy practice because it showed that plant staff members have added an item of equipment to save electricity when an easier, less-efficient approach could have worked. As such, blowers can be considered an indicator of market conditions related to compressed air.

$(\text{BlowerHP})_n =$ TotalBlowerhp

= Average of TotalBlowerHPRange_low and TotalBlowerHPRange_high, if TotalBlowerHPRange_low and TotalBlowerHPRange_high if both are > 0. Otherwise

= 0, if Q8 = “None” (this variable was not included in the variable list)

Automated Lubrication
Phase 1, Questions 9 and 10; Phase 2, Questions 8 and 9
Relevance: Over- and under-lubrication wastes energy. It is expected that automated lubrication systems reduce over- and under-lubrication. These questions track the frequency of presence of such systems. Typically, auto-lubrication systems exist as an option on packaged equipment when they are bought, rather than being retrofit measures. It has been postulated that their popularity is increasing. Tracking this data element over time will reveal if this is true.

Energy Management Training
Phase 1, Questions 17–20; Phase 2, General Sections Questions 14 and 15
Relevance: A reported barrier to energy-efficiency upgrades is lack of understanding of technical issues. These questions indicated the extent to which industrial managers have received recent technical training on energy efficiency.

4.2.3.6 Gas Process Heating Section

Exhibit 4-30 shows the analysis conducted for the Gas Process Heating Section.

Exhibit 4-30. Analysis Conducted for Gas Process Heating Section

Data Attribute	Linked Technologies/ Behaviors	Phase 2 Question Number(s)*	Notes on Analysis	Analysis
Technology Shares, Costs, and Quantities				
Facility uses gas that is at least 10,000 therms/yr or $5,000/yr		1		Proportion
Total dollar amount per year for gas process-heating loads		2	If given as a range instead of exact number, use midpoint	Average
What categories use gas for process heat?		5		Proportions
Which gas process heating energy-efficiency options are installed? In the last 3 years?		6		Proportions
Indicators of Practices Relating to Energy Efficiency				
Which changes were made to the boiler after installation? In the last 3 years?		7		Proportions
Which maintenance measures are performed on the gas process heat system?	Maintenance	8		Proportions

*Gas Process Heating data only collected in Phase 2.

Relevance of Selected Item to Energy Policy

Presence of Energy-Efficiency Measures
Phase 2, Questions 6-8
Relevance: These questions detected presence of several energy-efficient measures that would apply to gas process heating systems. For these measures, observations were made on whether the item was present (saturation) and whether it was added in the last three years (market share).

4.2.3.7 Electronic Control of Process Equipment Section

Exhibit 4-31 shows the analysis conducted for the Electronic Control of Process Equipment Section.

Exhibit 4-31. Analysis Conducted for Electronic Control of Process Equipment Section

Data Attribute	Linked Technologies/ Behaviors	Phase 1 Question Number(s)	Phase 2 Question Number(s)	Notes on Analysis	Analysis
Technology Shares, Costs, and Quantities					
Percentage of firms with electronic process controls equipment …		1	1		Proportion
Cost of control system		14	14		Average
Incremental price premium for energy saving features		15	15		Average
Market Characterization Attributes and Indicators of Energy Efficiency Practices					
Who maintains the control system?		6	6		Distribution
Regularly recalibrated/ recommissioned?		7	7		Distribution
Electrical demand of process(es) under automatic control (hp)		4	4		Average
Electrical demand of process(es) managed with energy saving controls (hp)		5	5		Average
Controls dedicated to energy savings?		13	13		Distribution
Decision Factors					
Why installed energy saving control system?			2, 3		Distribution
Who initiated idea?		9	9		Distribution
Who decided on design?		10	10		Distribution
Who gave final approval?		11	11		Distribution
Market Pathways					
Who sold you the control system?		8	8		Distribution
How become aware of new products			16		Distribution

Relevance of Selected Items to Energy Policy

Total Electric Demand Under Control
Phases 1 and 2, Question 5
Relevance: This is an indicator of market share for electronic process controls used to reduce peak demand or save energy. It is not a direct market share, because determining the total amount of demand theoretically controllable by such controls was beyond the scope of the study.

Maintenance of Control System
Phases 1 and 2, Questions 6 and 7
Relevance: Responses are an important behavioral indicator. According to one expert interviewed in advance of the survey, decreases in control system demand and energy savings due to inadequately serviced control systems constitutes a significant problem that can be largely remedied with routine service, either by on-site staff or a contractor.

4.2.3.8 Water Recovery and Reuse Section

Exhibit 4-32 shows the analysis conducted for the Water Recovering and Reuse Section. An explanation of how recovered flow rate was calculated follows the table.

Exhibit 4-32. Analysis Conducted for Water Recovery and Reuse Section

Data Attribute	Phase 1 Question Number(s)	Phase 2 Question Number(s)	Notes on Analysis	Analysis
Technology Shares, Costs, and Quantities				
Percentage of establishments with water reuse and recovery	1	4		Proportions
Cost of water recovery system	10	11		Average
Presence of heat recovery	6	7		Proportion
Amount of heat recovery	7	8		Average
Average percent recovered	2, 5	1, 6		Formula
Market Pathways				
Who initiated idea to install?	13	14		Proportions
Who decided on design?	14	15		Proportions
Who decided to buy?	15	16		Proportions
How become aware of new products	NA	3		Proportions
Decision Factors				
Why was the system installed?	16, 17	17, 18		Proportions
Other Market Characterization Attributes				
Wastewater flow rate	2	1	Choices changed in P2, in P1 skipped if no reuse system. Assigned point estimate into bins.*	Proportion of each choice under "3rd most desirable".
Are anticipated savings being realized?	18	19		Proportions
Are savings monitored?	12	13		Proportions
How much cost is saved per year?	12	13		Average

*P1= Phase 1, P2 = Phase 2

Average Percentage of Wastewater Recovered for Reuse

For respondents who gave a number rather than a percentage range of wastewater flow, Aspen defined:

PercentRecovered = RecoveredGPD/GPD,

Where, for Phase 2:

GPD = DailyWaste, if DailyWaste > 0
= 5,000 if WasteFlow =”less than 10,000 gallons per day”
= 17,500 if WasteFlow =”10,000 to 25,000 gallons per day”
= 62,500 if WasteFlow = “25,001 to 100,000 gallons per day”
= 150,000 if WasteFlow = “100,001 to 200,000 gallons per day”
= 350,000 if WasteFlow = “200,001less than 500,000 gallons per day”
= 750,000 if WasteFlow = “500,001 to 1,000,000 gallons per day”
= Missing if WasteFlow = “Don’t know”

And for Phase 1:

GPD = Daily waste, if Daily waste > 0
= 12,500 if WasteFlow = ”less than 25,000 gallons per day”
= 62,500 if WasteFlow = “25,001 to 100,000 gallons per day”
= 150,000 if WasteFlow = “100,001 to 200,000 gallons per day”
= 350,000 if WasteFlow = “200,001less than 500,000 gallons per day”
= 750,000 if WasteFlow = “500,001 to 1,000,000 gallons per day”
= Skip if WasteFlow = “Don’t know”

RecoveredGPD = DailyRecycled, if DailyRecycled > 0 and RateUnit = “gallons per day”
= DailyRecycled * 60 * HrPerDay, if DailyRecycled > 0 and RateUnit = “gln per min.”
= Missing if RecycleFlow = “Don’t know”
If PercentRecovered > 100%, set PercentRecovered to 100%.

4.2.3.9 Refrigeration Section

Exhibit 4-33 shows the analysis conducted for the Refrigeration Section. Following the exhibit is a discussion of five attributes of the Refrigeration Section that required further specification.

Exhibit 4-33. Analysis Conducted for Refrigeration Section

Data Attribute	Linked Technologies/ Behaviors	Phase 1 Question Number(s)	Phase 2 Question Number(s)	Notes on Analysis	Analysis
Technology Shares, Costs, and Quantities					
Percentage of firms with refrigeration systems >20 horsepower		2	1		Proportion
Heat recovery cost		9	8		Average
Floating head cost		14	13		Average
Ammonia system/conversion cost		19	18		Average
VSD cost	VSDs	24	23		Average
Heat recovery bought in last five years		3	2		Proportion
Floating head bought in last five years		10	9		Proportion
Ammonia refrigerant bought in last 5 years		15	14		Proportion
VSD tower fans bought in last five years	VSDs	20	19		Proportion
Heat recovery saturation		25, 26	24, 25		Ratio
Floating head saturation		25, 27	24, 26		Ratio
Ammonia refrigerant saturation		25, 28	24, 27		Ratio
Screw VSD saturation	VSDs	29, 30	28, 29		Ratio
Cooling tower VSD saturation	VSDs	31, 32	30, 31		Ratio
Market Pathways					
Who performs refrigeration work		33	32		Proportions
Decision Factors					
Heat recovery decision factors		5, 6	4, 5		Proportions
Floating head decision factors		12, 13	11, 12		Proportions
Ammonia decision factors		17, 18	16, 17		Proportions
VSD tower fans decision factors	VSDs	22, 23	21, 22		Proportions
Other Market Characterization Attributes					
Heat recovery source		7	6		Proportions
Heat recovery use		8	7		Proportions
Heat recovery considered		4	3		Proportion
VSD tower fans considered	VSDs	21	20		Proportion
Floating head considered		11	10		Proportion
Ammonia refrigerant considered		16	15		Proportion

Five attributes of the Refrigeration Section require further specification:

$$\text{Heat recovery saturation} = \Sigma\, [(\text{WithHeatRecoveryHP})_n * (\text{Population Weight})_n\,] \,/\, \Sigma\, [\,(\text{TotalRefrigHP})_n * (\text{Population Weight})_n\,]$$

$$\text{Floating head saturation} = \Sigma\, [(\text{WithFloatingHeadCtl})_n * (\text{Population Weight})_n\,] \,/\, \Sigma\, [\,(\text{TotalRefrigHP})_n * (\text{Population Weight})_n\,]$$

$$\text{Ammonia refrigerant saturation} = \Sigma\, [(\text{AmmRefrigHP})_n * (\text{Population Weight})_n\,] \,/\, \Sigma\, [\,(\text{TotalRefrigHP})_n * (\text{Population Weight})_n\,]$$

$$\text{Screw VSD saturaton} = \Sigma\, [(\text{ScrewVSDHP})_n * (\text{Population Weight})_n\,] \,/\, \Sigma\, [\,(\text{ScrewCompreHP})_n * (\text{Population Weight})_n\,]$$

$$\text{Cooling tower VSD saturation} = \Sigma\, [(\text{CoolFanVSDHP})_n * (\text{Population Weight})_n\,] \,/\, \Sigma\, [\,(\text{CoolFanHP})_n * (\text{Population Weight})_n\,]$$

Relevance of Selected Items to Energy Policy

Refrigeration Heat Recovery

Phase 1, Questions 3–9, 25, and 26; Phase 2, Questions 2–8, 24, and 25

Relevance: Refrigeration is the process of removing thermal energy (“heat”) from a product or process to cool it, and depositing that energy elsewhere. The deposited energy, normally in the form of hot air or water, includes not just the energy removed from the product or process, but also the thermal equivalent of the electrical energy supplied to the refrigeration equipment itself. In most cases, the heat is simply rejected outside of the plant to ambient air through a condenser or cooling tower.

While the energy is normally rejected in the form of “low-grade heat,” which means air or water that is only moderately warmer than surroundings, sometimes a portion of it can be used elsewhere in the plant. The most common applications are to pre-heat water going to a boiler, or to warm air for employee comfort in the winter. Recovered heat generally displaces purchased energy on a one-for-one basis. It is not a common energy-efficiency technology because the low- grade nature of the available heat makes it relatively expensive to capture, and there are relatively small requirements for thermal energy in this low temperature range. These questions measure the market share, level of activity, and applications for which refrigeration heat recovery is in use in California.

Floating Head Control

Phase 1, Questions 10–14, 25, and 27; Phase 2, Questions 9–13, 24, and 26

Relevance: In order for a refrigeration system to reject heat from refrigerant to the outside air, the refrigerant leaving the compressor must be hotter than outside. This is in fact the main job of the compressor, to compress refrigerant so that it is at a high pressure and temperature.

According to the Energy Center of Wisconsin:

> "In many refrigeration systems, compressor discharge (head) pressure is kept at a fixed, high level to assure safe, reliable operation over a range of outdoor temperatures. Fixed high head pressure maintains adequate refrigerant flow, freeze protection for the evaporative condenser, and an adequate pressure difference across the expansion valve. But fixed head pressure isn't the only way to provide these assurances.
>
> "It's far more efficient to allow head pressure to "float" with ambient wet-bulb temperature, down to a minimum safe level for a given system. With floating head pressure, the system works only as hard as it needs to under all weather conditions, yet safety and reliability are maintained. When head pressure floats, the evaporative condenser fan operates continuously instead of cycling on and off. Although this consumes more condenser fan energy, it is more than compensated by the much larger decrease in compressor energy use. In addition, eliminating fan starts and stops can prolong fan belt and motor life. And because floating head pressure reduces compressor operating pressure ratios, it greatly reduces wear on compressor parts."[11]

Floating head is not universally applicable. Appropriateness depends on system size, refrigerant, condenser type and relative size, and the possibility of incorporating a refrigerant pump or subcooling to ensure the proper quality liquid refrigerant is delivered to the expansion valve after it leaves the condenser.

Ammonia Refrigeration

Phase 1, Questions 15–19, 25, and 28; Phase 2, Questions 14–18, 24, and 27

Relevance: Generally, ammonia-based refrigeration systems are more efficient than systems using other common refrigerant fluids, but there are other equipment and safety issues that make ammonia impractical for some manufacturers.

4.2.3.10 Power Generation Section

Exhibit 4-34 shows the analysis conducted for the Power Generation System Section.

Exhibit 4-34. Analysis Conducted for Power Generation Section

Data Attribute	Phase 1 Question Number(s)	Phase 2 Question Number(s)	Notes on Analysis	Analysis
Technology Shares, Costs, and Quantities				
Percentage with emergency backup	1	1		Proportion
Percentage with routine power	4	4	If “No” skip to Q12 in P2, skip to end in P1*	Proportion
Presence of cogeneration	7	7		Proportion
Cogeneration kW	8	8		Sum
Emergency backup system type	2	2		Proportions
Routine power system type	5	5		Proportions
Market Pathways				
How become aware of new products	NA	11		Proportions
Other Market Characterization Attributes				
Hours per week of use	9	9		Average
Percent of routine power for peak reduction	8, 10	8, 10		Ratio
Percentage with routine power planning on adding more	11	12		Percentage

*P1= Phase 1, P2 = Phase 2

The percent of routine power used for peak reduction was calculated as:

$$\Sigma\, [(\text{PeakShavekW})_n * (\text{Population Weight})_n\,] \,/\, \Sigma\, [\,(\text{PlantkW})_n * (\text{Population Weight})_n\,]$$

Where: PeakShavekW = PeakShave * PlantkW

And: PeakShave = 1 if PeakShavSysUsed = “Yes” for Q10, else = 0

Relevance of Selected Items to Energy Policy

Installed Cogeneration
Phases 1 and 2, Questions 7 and 8
Relevance: Total installed cogeneration capacity is a trending indicator that can be compared with results from future studies. If divided by the total installed industrial peak demand by all investor-owned utilities (IOUs), which is not in the scope of this survey, it would represent the industrial market share for cogeneration.

On-Site Power Used for Peak Shaving
Phases 1 and 2, Questions 8 and 10
Relevance: This ratio tracks the percentage of customers that use non-emergency on-site generation capacity specifically for peak demand shaving to reduce their demand charges.

4.2.4 Detection of Potential for Non-Response Bias

If the sample on which the survey was conducted differs from the population from which the sample was selected with regard to practices relating to energy-efficiency, non-response bias may cause the estimates of items such as market shares from the data gathered in the survey to be skewed relative to the true population values. Direct detection of non-response bias is not generally possible, since non-responders by definition do not provide data. However, some evidence on the potential for non-response bias may be gathered by analysis of data available. Though many establishments refused to participate in an on-site survey, some of the refusers answered a few questions about their facilities during the telephone surveying.

For Phase 1, the following questions were asked during telephone surveying:

- Does any part of your manufacturing process equipment have electronic controls that automatically unload or turn off equipment when the equipment is not in use?

- Do you operate a power generation plant that provides electricity for regular use? This does not include power plants used just for emergency backup purposes.

- Do you have refrigeration systems totaling 20 horsepower or more that you use for process cooling or food storage?

- We've defined a water-recovery system as any process that reuses water-based discharge fluids, thereby reducing or eliminating wastewater discharge from the site. Given that definition, do you have a water-recovery system at your facility?

For Phase 2, the power generation and refrigeration questions were replaced with:

- Do you have a boiler system to provide process steam and/or hot water?
- Do you have 50 horsepower or more of non-backup process pumps?

The surveyor coded all answers to these questions into one of the following categories:

- Yes
- No
- Doesn't know / Refuses to answer

Aspen performed distributional analyses for each of these questions for Phases 1 and 2. By stratum, for each of the questions enumerated above, Aspen created a contingency table with the answers to the question contained as a row variable and whether or not an on-site survey was conducted contained as a column variable. Aspen then examined chi-square statistics for evidence of significant difference between the answers of the establishments completing surveys vs. the answers of establishments that did not complete an on-site survey, but did answer questions on their technologies during the telephone survey.

Since the sample sizes within strata were often small, use of estimated asymptotic p-values for chi-squared statistics would likely be misleading. For small samples, Fisher's Exact chi-square p-values are more appropriate. For each contingency table, Aspen calculated the Fisher Exact p-value for each stratum for which the data supported such calculation. The p-value fell below 0.05 in only 1 case, which under the null hypothesis of no differences, one might expect by chance, given the number of p-values calculated. Since the stratum sizes are relatively small, the tests are weak. However, the tests provide some evidence that sample selection bias is not a major cause for worry.

4.3 Upstream Market Actor Survey Data

4.3.1 Introduction

The purpose of the upstream market actor surveys was to supplement information available from other projects external to the tracking study, as described above in Section 4.1. The CEC's request for proposal specified that primary data related to nonresidential market attributes of the following five technologies be collected:

- Lighting
- Chillers
- Windows
- Refrigeration
- Energy management systems

After discussions with CEC, it was subsequently decided that data collection pertaining to refrigeration and energy management systems performed in the Industry Energy End-User Survey sufficient for these technologies and attention should be focused on the other three.

Aspen's approach to this task consisted of the following steps:

- Develop a list of market attributes for which data should be gathered.
- Prepare a plan for obtaining and stratifying sample frames, preparing questionnaires, and conducting the surveys. Document the plan and submit it to the CEC project manager for review and comment.
- Develop survey questionnaires and submit them for approval. Also, acquire and stratify the sample frames in accordance with the approved survey plan.
- Pre-test the approved questionnaires; revise questionnaires as needed as a result of the pre-tested experience.
- Conduct telephone survey interviews, documenting the outcome of each attempted completion.
- Compile a temporary database of survey responses; perform QC and check entries. Finalize database and transfer cleaned data to the Confidential Database.
- Analyze call records and calculate the percentage of ineligible respondents; adjust the population counts accordingly and calculate weighting factors using the latter figures.

- Develop and document the analysis plan for each survey; submit plan to the CEC project manager for review and comment.
- Analyze survey data in accordance with the approved plan. Compile analysis results in the Public Database. Interpret survey results and prepare this section of the final report.

The market attributes for which data were to be collected for each technology were:

- Market shares of energy-efficient versions
- Prices of energy-efficient and standard-efficiency versions
- Market pathways that represent product flows
- Roles of key decision-makers who affect selection of energy-efficient versions
- Customer preferences, decision factors, and barriers to purchasing energy-efficient versions
- Other market characterization data, such as equipment delivery times, the effect on sales of California's 2001 "energy crisis, " which featured rolling blackouts and price volatility

Although market share and price data are highly valued, Aspen recognized that accurate and precise data for these attributes would be very difficult to obtain because it requires detailed sales data, which manufacturers and vendors consider to be proprietary. Data concerning market pathways for product flows, identification of key decision-makers, and customer decision factors is more readily provided during surveys. Exhibit 4-35 presents a matrix showing for each technology the market actors surveyed for each grouping of market attributes.

Exhibit 4-35. Market Actor – Technology – Market Attribute Matrix

Technology	Source for Market Share and Prices	Source for Market Pathway, Efficiency Selector, and Customer Preferences
Lighting	Lighting Equipment Distributors and Wholesalers Manufacturers	Lighting Designers Lighting Equipment Distributors and Wholesalers Manufacturers
Electric Chillers	Manufacturers Chiller Contractors	Chiller Contractors Manufacturers
Windows	Window Suppliers (some are also manufacturers and/or contractors)	Window Suppliers (some are also manufacturers and/or contractors)

4.3.2 Sampling Plan

4.3.2.1 Building the Sampling Frames

Once the market actor categories were selected, Aspen developed lists of specific firms in each segment from which to draw the sample. To be a suitable frame, the list had to:

- Be complete (contain the entire target population)
- Contain as few out-of-scope firms as possible
- Contain accurate and detailed contact information (name and telephone number at a minimum) for each firm
- Contain a complete address for each firm
- Contain at least one indicator of firm size

The following series of steps were followed to select sample frames for the six market-actor segments listed in Exhibit 4-35:

- **Establish SIC codes.** Because the various sources of business data and lists use SIC and NAICS codes to classify businesses by type, Aspen first had to select appropriate primary and secondary codes for each market-actor segment. It should be noted, however, that SIC codes inherently include many types of businesses that are clearly outside the scope of this project. That is, even the 4-digit SIC code designations are overly broad for effective use in identifying specific lists of firms to contact for the purposes of this survey. For example, the category of "Lighting Equipment Wholesalers and Distributors" is very specific for this study's needs, but is one of almost 40 business types included in SIC 5063. This difficulty has been observed in every NAICS and SIC pertinent to these surveys. The way we circumvented this problem is to use more tightly defined codes, such as those used by firms that sell commercial lists. Exhibit 4-36 shows the six-digit codes used by *InfoUSA* that we selected for the six market-actor segments to be surveyed. As will be shown in Section 4.3.3, even these six-digit codes inevitably still include some out-of-scope firms in the lists.
- **Estimate populations for each market actor category.** This step involved determining the total number of California firms that comprise the population of each market-actor segment. To do this, Aspen used the U.S. Census Bureau's *County Business Patterns* data and other information sources, such as *Yellow Pages* databases, to develop these estimates.
- **Obtain lists of businesses for each segment.** Sources of business-contact lists include directories such as the *Thomas Register* and the telephone company's California statewide *Yellow Pages* listings, as well as commercial firms, such as the *InfoUSA,* that sell this type of data products.

Exhibit 4-36. SIC Codes for Market Actors

Technology	Primary SIC Codes*	Secondary SIC Codes*	Comments
Lighting Equipment Wholesalers and Distributors	5063-19, 5063-78		The two primary SIC Codes include wholesalers of both lighting fixtures and lamps
Lighting Designers	8711-46, 8712-02	1731-26, 8711-15, 8712-05, 8712-06, 8748-92, 8712-17, 1521-06, 8712-11	Architects and lighting engineers are the primary two sectors. Secondary SIC Codes include architectural designers, architectural and construction specifiers, architectural consultants, architectural designers, electrical engineers, electrical designers, architectural engineers, designers, and architecture and engineering firms.
Lamp Manufacturers	3645-03	3641-01	The major lamp manufacturers are not in California.
Ballast Manufacturers	3645-01	None	The major ballast manufacturers are not in California.
Lighting Equipment Manufacturers	3229-04, 3641-02 3645-01 3645-04 3646-98	None	Manufacturers of lighting fixtures, lighting equipment, commercial and industrial lighting.
Chiller Manufacturers	3585	None	The four major chiller manufacturers are not in California.
Chiller Contractors	1711-14, 1711-17, 7623-04	8712-05, 8712-06	Mechanical contractors, air conditioning contractors, and air conditioning and service contractors are the primary sectors. Secondary SIC Codes include architecture & engineering firms and architectural engineers.
Nonresidential Windows	5211-06, 5211-07, 5211-08	7536-01	Window contractors (including glazing contractors, metal and wood frame windows) are the primary sector. Secondary SIC Codes include window coating and tinting contractors.

* The six digit SIC designations assigned by *InfoUSA* consist of the standard four-digit SIC index, plus an additional two digits assigned by *InfoUSA* that correspond to specific market subcategories.

Aspen reviewed Web site literature describing commercially available business mailing lists. Based on cost and relevance of the data fields provided, Aspen purchased a data file from *InfoUSA*. This data file contained a total of 10,480 company records for California-based companies covering all desired segments except Chiller Manufacturers. This data file provided the following discrete fields of data:

- Company name
- Mailing address
- Street address
- Contact first and last name, title, and gender

- Telephone and fax number
- Corporate Web site URL
- Primary and secondary 6-digit SIC codes
- Primary and secondary SIC descriptions
- Reported annual sales volume
- Range of sales volume
- Employee size
- Range of employee size
- Franchise/specialty line(s) of business
- Metropolitan area

There are only four major electric chiller manufacturers in the United States; none is in California. A separate list was prepared from industry directories. Also, the major lamp and ballast manufacturers are also located outside of California. Again, a list of these firms was prepared from industry directories.

- **Create sampling frames from these lists.** The data file received from *InfoUSA* was separated into a set of five ACCESS 97 files, one for each market actor segment as defined by the six-digit SIC codes shown in Exhibit 4-36. These five sampling frames covered:
  - Lighting equipment wholesalers and distributors
  - Lighting designers
  - California-based lighting equipment manufacturers
  - Chiller contractors
  - Window suppliers

4.3.2.2 Stratifying the Sample

Using sales volume as a ranking criterion, specific market actor data elements were arranged into columns in five spreadsheets, under these headings:

- Count
- Company name
- Actual sales volume (for 2001)
- Sales volume category
- Sales volume range
- Cumulative sales
- Primary SIC
- Secondary SIC

Next, using the Dalenius-Hodges methodology to select stratum boundaries[12], four statistically defined size strata [small (S), medium (M), large (L), and very large (VL)] were defined based on sales volume, and each firm on the *InfoUSA* list was assigned to a stratum.

4.3.2.3 Selecting the Sample

Once the stratified sampling frames were created, Aspen used a random number method to prepare the call list (i.e., the sequence by which companies in each size category were to be called for each market-actor segment).

A total of 104 survey completions were decided upon via discussions with the CEC project manager. Aspen allocated this total among the six market-actor categories. Exhibit 4-37 shows the population (N) and the target final sample size (n) for each size category in each market-actor segment. The column labeled “X-CA” lists the firms located outside of California.

Exhibit 4-37. Population and Sample Sizes for the Six Market-Actor Segments

Segment	Population (N)	Sales-Volume Size Category				X-CA	ALL
	Sample (n)	S	M	L	VL		
Lighting Wholesalers	N	101	85	29	15		230
	n	9	11	2	1		23
Lighting Designers	N	2,032	2,299	487	161		4,979
	n	7	7	5	4		23
Lighting Manufacturers	N	17	10	8	3	5	43
	n	2	2	2	0	1	7
Chiller Manufacturers	N					4	4
	n					4	4
Chiller Contractors	N	1,516	1,198	357	137		3,208
	n	9	11	2	1		23
Window Suppliers	N	258	231	99	46		634
	n	7	7	5	5		24

4.3.3 Data Collection

4.3.3.1 Data Collection Instruments

A separate questionnaire was developed for each of the six segments. Questions were based on the overall project objectives, the information provided in the scoping study, and the market attributes listed in Exhibit 4-35.

After draft versions were reviewed and approved by the CEC project manager, the questionnaires were pre-tested by calling eight respondents, including at least one respondent in each segment. As a result of experience with the pre-test, a few small wording changes were made and resubmitted for approval. Calls to potential respondents began as soon as final approval was obtained. Copies of the final survey questionnaires are provided in Appendix C.

4.3.3.2 Survey Procedure

The telephone interviews were conducted using mid-level and senior staff members who had engineering degrees and were familiar with the three technologies, and had extensive experience conducting surveys involving market actors. A letter documenting the purposes of and reasons for the survey was prepared and would be sent via fax or e-mail if the respondent expressed concern about the legitimacy of the survey. In addition, a brief introductory script explaining the purpose of the call was prepared.

Each interviewer followed the same set of procedures to complete the surveys, including:

- Become familiar with the questionnaire, introductory script, the call list, and the target quotas for each size category. Interviewers were encouraged to adapt the introductory script to suit their own style of speaking.
- Once a person at the called company was on the line, attempt to develop a rapport with the respondent. Explain the importance of the survey and potential benefits, and that the respondent has important knowledge about his/her industry that will help us to better understand the market. Offer to fax or e-mail a letter that documents purposes of and reasons for the survey. Determine whether a different time to conduct the interview would be preferred. (Aspen has found that making this offer is taken as an indication that we are treating the respondent with respect, and that in most instances the offer results in the response, “No, let’s do it now.”)
- Write a summary of all comments made by respondents that provide additional insights into market behaviors, pathways, and decision factors.
- For those cases where detailed sales and price data are requested, offer to fax or e-mail the two-page form; emphasize that data in any form available is appreciated. Make a follow-up call every few days to encourage submittal of the data.
- Complete a call record sheet for each contact to keep track of the number of attempts made to complete a survey with each company, as well as the final disposition of the contact(s). (A set of 14 standardized Call Disposition Codes were used in this activity.) Up to four attempts were made to reach a qualified respondent at each company on the call list. Some flexibility was permitted in meeting completion quotas within each size category (e.g., sometimes respondents in a given category would call back after the quota for a category was reached).

When the targeted total number of calls for a given market-actor segment was reached, the call records were tabulated and analyzed to determine:

1) Out-of-scope fraction: The number of companies that were out of business or in a different business, divided by the total number of companies called.
2) Refusal fraction: The number of companies that refused to be surveyed divided by the total number of companies called.

4.3.3.3 Database Preparation

Entries on each questionnaire were entered into a database (EXCEL spreadsheet). All entries were checked by the data QC supervisor. (Because the targeted number of respondents in each individual survey was 24 or fewer, it was not cost-effective to develop software-driven data-input screens with automatic QC checking, as had been done for the Industry Energy End-User Survey.)

4.3.3.4 Quality Assurance and Control

Quality assurance and control measures for this task were reflected in the following aspects of the methodology:

- Preparation of a detailed survey plan document as an initial activity.
- Using experienced mid-level or senior staff members to conduct the interviews.
- Having the data QC supervisor check all data entry activities.
- Calculating refusal rates for each market actor segment to identify if there is a significant potential for non-response bias.

Once QC was completed, all data were loaded into tables in the Confidential Database and analysis began.

4.3.4 Data Analysis Plans

4.3.4.1 Weighting Factors and Refusal Rates

As was noted previously, data collection via surveys inevitably involves the inclusion on the call list of prospective respondents who are out-of-scope (i.e., individuals or firms whose characteristics do not fully conform with those of the targeted group). For this reason, one or more screening questions are included at the beginning of a survey question. As was mentioned in Section 4.3.3.2, a Call Disposition Code is entered on the call record form for each call. The fraction of out-of-scope companies was calculated for each market actor category. The result was used to obtain an estimate of the actual population of companies for each category:

[Actual Population] = [Gross Population] x [1.0 – Out-of-Scope Fraction]

where: Gross Population is the population based on the *InfoUSA* lists (Exhibit 4-37)
Out-of-Scope Fraction is calculated as described in Section 4.3.3.2.

Exhibit 4-38 presents the results of this analysis and the resulting weighting factors for the five surveys that used Call Lists generated from the *InfoUSA* data file. The exhibit also provides the calculated refusal rates. From the latter, Aspen concludes that non-response bias is not likely to be a significant issue for these surveys. The refusal rates range from 0 percent to 10 percent in five of the six segments surveyed, causing little concern for non-response bias. In the sixth segment, the refusal rate was 17 percent, but analysis of responder characteristics disclosed no reason to suspect non-response bias was occurring. Survey information was obtained from all four chiller manufacturers also, but the weighting factor is unity for all four respondents.

Exhibit 4-38. Weighting Factors and Refusal Rates

Lighting Wholesalers and Distributors

Size Category	n	Gross N	Actual N	Weighting Factor
VL	1	15	13	13.20
L	2	29	25	12.76
M	13	85	75	5.75
S	7	101	89	12.70
	23	**230**	**202**	

Out-of-Scope Fraction = 0.12
Refusal Rate: = 17%

Lighting Manufacturers

Size Category	n	Gross N	Actual N	Weighting Factor
VL	1	8	7	7.00
L	2	8	7	3.50
M	2	10	9	4.50
S	2	17	16	8.00
	7	**43**	**39**	

Out-of-Scope Fraction = 0.08
Refusal Rate: = 10%

Lighting Designers

Size Category	n	Gross N	Actual N	Weighting Factor
VL	6	161	105	17.44
L	5	487	429	85.71
M	4	2299	2023	505.78
S	8	2032	1788	223.52
	23	**4979**	**4345**	

Out-of-Scope Fraction = 0.35
Refusal Rate: = 0%

Chiller Contractors

Size Category	n	Gross N	Actual N	Weighting Factor
VL	9	137	111	12.33
L	5	357	289	57.83
M	6	1198	970	194.08
S	4	1516	1228	306.99
	24	**3208**	**2598**	

Out-of-Scope Fraction = 0.19
Refusal Rate: = 7%

Window Suppliers

Size Category	n	Gross N	Actual N	Weighting Factor
VL	1	46	24	23.92
L	8	99	51	6.44
M	6	231	120	20.02
S	9	258	134	14.91
	24	634	**329**	

Out-of-Scope Fraction = 0.48
Refusal Rate: = 2%

4.3.5 Data Analysis

A data analysis plan was prepared for each survey segment. These plans are provided in the following six exhibits. Four abbreviations were used in these plans:

EE = Energy efficiency
SE = Standard efficiency
NC = New Construction
R/R = Renovation/Retrofit

As was noted previously, the questionnaires containing the specific questions referred to in the plans are provided in Appendix C.

Lighting

Exhibits 4-39, 4-40, and 4-41 present the data analysis plans for the Lighting Equipment Distributors and Wholesalers, Lighting Designers, and Lighting Equipment Manufacturers Segments, respectively.

Exhibit 4-39. Analysis Plan for Lighting Equipment Wholesalers and Distributors Segment

Market Attribute	Survey Questions	Analysis Procedure
Market Share of Energy Efficient Features	Data tables provide sales volumes (numbers of units sold) for standard and various energy efficient lighting products.	If 3 or more responses: Calculate average market shares: T12(34W) Sales / (All T12 Sales) T8 Sales / (T8 Sales + All T12 Sales) El. Ballast Sales / All Ballast sales Dim. Ballast Sales / All Ballast sales 2-Step Ballast Sales / All Ballast sales LED Exit Sign Sales / All Exit Sign Sales
Price Data	Data tables provide sales volumes ($) for standard and various energy efficient lighting products.	Calculate mean prices ($/unit) for all lighting products for which there are three or more responses
Market Pathways	Q8 provides the distribution of the sources of lighting products sold to others.	Mean for each category
	Q9 provides the distribution of revenues by customer type.	Mean for each category
	Q11 provides the distribution of revenues by NC and R/R subsectors.	Mean for each category
Other Market Characterization Attributes	Q2 informs whether company sells EE products.	Proportions
	Q3 informs whether company sells SE products.	Proportions
	Q4 informs whether lighting design services are also provided.	Proportions
	Q5 concerns the company’s sales volume	Mean

Exhibit 4-40. Analysis Plan for Lighting Designers Segment

Market Attribute	Survey Questions	Analysis Procedure
Market Share of Energy Efficient Features	Q24 provides the percentage of designs that are 20% or more below Title 24 requirements. Q28 provides frequencies that various energy efficient features are included in designs.	Mean Mean for each feature
Price Data	Not included	
Market Pathways	Q5 provides the distribution of revenues by client type. Q6 provides the distribution of total revenues by NC and R/R subsectors. Q8 provides the distribution of revenues from lighting product sales by NC and R/R subsectors.	Mean for each category Mean for each category Mean for each category
Customer Preferences, Decision Factors, and Barriers to Selecting EE Features	Q10 identifies features clients usually initially request in a design project. Q11 identifies features clients often later eliminate as the design evolves. Q18 informs concerning client economic decision-making criterion. Q21 informs how frequently highly efficient designs are proposed. Q22 informs how frequently clients reject these proposals. Q23 identifies “frequently cited” and “infrequently cited” reasons clients reject proposals. Q26 concerns perceived differences in preferences of clients in the NC and R/R markets.	Proportions Proportions Proportions Proportions Proportions Proportions Proportions
Other Market Characterization Attributes	Q1 concerns the company’s business activities. Q3 concerns products sold. Q4 concerns the company’s sales volumes (design services and product sales). Q12 informs whether company is familiar with rebate programs. Q13, Q14, Q16, & Q17 provide data concerning program involvement. Q15 concerns frequency of projects applying for rebates. Q25 concerns effects of design assistance programs.	Proportions Proportions Mean for each category Proportions Proportions Mean Proportions

Exhibit 4-41. Analysis Plan for Lighting Equipment Manufacturers Segment

Market Attribute	Survey Questions	Analysis Procedure
Market Share of Energy Efficient Features	Data tables provide sales volumes (numbers of units sold) for standard and various energy efficient lighting products.	If 3 or more responses: Calculate average market shares: T12(34W) Sales / (All T12 Sales) T8 Sales / (T8 Sales + All T12 Sales) El. Ballast Sales / All Ballast sales Dim. Ballast Sales / All Ballast sales 2-Step Ballast Sales / All Ballast sales LED Exit Sign Sales / All Exit Sign Sales
Price Data	Data tables provide sales volumes ($) for standard and various energy efficient lighting products.	Calculate mean prices ($/unit) for all lighting products for which there are three or more responses
Market Pathways	Q7 provides the distribution of revenues by customer type for sales of lamps and ballasts. Q8 provides the distribution of revenues by NC and R/R subsectors for sales of lamps and ballasts.	Mean for each category Mean for each category
Other Market Characterization Attributes	Q2 concerns the company's geographic scope of operations. Q3 concerns the company's product lines. Q4 concerns the company's sales volume (total and California).	Proportions Proportions Mean for each category

Chillers

Exhibits 4-42 and 4-43 present the data analysis plans for the Chiller Contractors and Chiller Manufacturers Segments, respectively.

Exhibit 4-42. Analysis Plan for Chiller Contractors Segment

Market Attribute	Survey Questions	Analysis Procedure
Market Share of Energy Efficient Features	Data tables provide sales volumes (numbers of units sold) for recip chillers and for screw or scroll chillers.	If 3 or more responses: Calculate average market shares for 3 size categories: Screw + Scroll Chiller Sales / (Recip + Screw + Scroll Sales) Availability of EE Features (VSD, Other) for Each Chiller Type: Whether Standard Feature or “Extra” Percentage Sold w/Feature (if “Extra”)
Price Data	Data tables provide price adder for each feature (if “extra”).	If 3 or more responses: Approximate Price Adder (%) for Feature
Market Pathways	Q4 provides the distribution of applications of chiller units sold. Q5 provides the distribution of chiller unit sales by NC and R/R subsectors. Q6 provides the distribution of sources of chillers purchased by selling-organization type. Q7 provides the distribution of sales revenues by customer type.	Mean for each category Mean for each category Mean for each category Mean for each category
Customer Preferences, Decision Factors, and Barriers to Selecting Energy Efficient Features	Q12 identifies frequency that various considerations are cited by customers when selecting a chiller. Q14 concerns the effect on sales of energy efficient chillers of various types of incentive programs. Q17 and Q18 concern delivery times for chillers in two size ranges. Q19 concerns additional delivery time for chillers with optional energy efficient features.	Mean for each consideration Mean for each type of program Mean for each size range Mean
Other Market Characterization Attributes	Q1 identifies the various products and services offered by the company. Q3 concerns products sold. Q4 concerns the company’s sales volumes (design services and product sales). Q8 provides total annual revenue. Q9 provides the percentages of revenues derived from various types of services. Q15 concerns effect of California’s “energy crisis” on chiller sales. Q16 concerns whether change persisted after the “energy crisis” abated.	Proportions Mean for each category Proportions Mean Mean for each type Proportions Proportions

Exhibit 4-43. Analysis Plan for Chiller Manufacturers Segment

Market Attribute	Survey Questions	Analysis Procedure
Market Share of Energy Efficient Features	Data tables provide sales volumes (numbers of units sold) for recip chillers and for screw or scroll chillers.	If 3 or more responses: Calculate average market shares for 3 size categories: Screw + Scroll Chiller Sales / (Recip + Screw + Scroll Sales) Availability of EE Features (VSD, Other) for Each Chiller Type: Whether Standard Feature or "Extra" Percentage Sold w/Feature (if "Extra")
Price Data	Data tables provide price adder for each feature (if "extra").	If 3 or more responses: Approximate Price Adder (%) for Feature
Market Pathways	Q3 provides the distribution of applications of chiller units sold. Q4 provides the distribution of chiller unit sales by NC and R/R subsectors. Q6 provides the distribution of sales revenues by customer type.	Mean for each category Mean for each category Mean for each category
Customer Preferences, Decision Factors, and Barriers to Selecting EE Features	Q8 identifies frequency that various considerations are cited by customers when selecting a chiller. Q10 concerns the effect on sales of energy efficient chillers of various types of incentive programs. Q13 and Q14 concern delivery times for chillers in two size ranges. Q15 concerns additional delivery time for chillers with optional energy efficient features.	Mean for each consideration Mean for each type of program Mean for each size range Mean
Other Market Characterization Attributes	Q2 provides the percentages of units, tons, and revenues for chillers sold in California. Q5 provides the percentages of units sold that are custom designed vs. a standard model. Q11 concerns effect of California's "energy crisis" on chiller sales. Q12 concerns if change persisted after the "energy crisis" abated.	Mean for each category Mean for each category Proportions Proportions

Windows

Exhibit 4-44 presents the data analysis plan for the Windows Suppliers Segment.

Exhibit 4-44. Analysis Plan for Window Suppliers Segment

Market Attribute	Survey Questions	Analysis Procedure
Market Share of Energy Efficient Features	Q20 provides data concerning the prevalence of energy efficient features.	Mean for each feature
Price data	Q21 provides the price of a baseline product Q22 provides percentage price increases for various energy efficient features.	Mean Mean for each feature
Market Pathways	Q4 provides the distribution of sources of windows sold to others. Q7 provides distribution of revenues by customer type. Q8 provides distribution of revenues by NC and R/R subsectors. Q18 identifies window brands sold.	Mean for each source Mean for each category Mean for each category List 5 most popular
Customer Decision Factors and Barriers to Selecting EE Features	Q23 provides the ranking of customer decision factors. Q24 identifies “frequently cited” and “infrequently cited” barriers or reasons for customers not including EE features when purchasing windows. Q25 provides data concerning propensity of purchasers to vary window design on different sides of a building. Q26 and Q27 provide data concerning delivery times for windows without and with energy efficient features. Q28 and Q29 provide data concerning perceived differences between the NC and R/R markets.	Mean for each factor Proportions Proportion Means Proportions
Other Market Characterization Data	Q10 identifies firms that are familiar with utility programs that promote the use of windows with energy efficient features. Q11, Q14, and Q16 provide data concerning program involvement. Q12 and Q13 provide data concerning the extent of direct involvement in program promotion. Q15 provides data concerning direct receipt of rebate checks.	Proportions Proportions Proportions Proportions

Notes

[1] Cochran, W., *Sampling Techniques*, New York, Wiley, 1977, pp. 128-130.

[2] The PG&E data expert who prepared the Phase 1 billing file indicated that a premise ID variable is available, but that it is obsolete.

3 The differences in the mean consumptions by stratum for the young accounts groups vs. the old accounts groups are striking. However, two facts should be noted. First, the number of establishments in the established accounts strata is over 25 times the number in the young accounts grouping. Thus, it is not surprising that there is wider variation in annualized consumption in the young accounts vs. the established accounts group. Second, the means in the table correspond to different percentile groupings for the established accounts strata vs. the young accounts strata. The large, young accounts stratum corresponds to consumers at roughly the 75th percentile and above in terms of electrical usage (excluding the top consumer, which was placed in the Certainty stratum). The large, established accounts stratum corresponds to the electrical usage of users above the 99th percentile in electrical consumption for the group, excluding the top 15 consumers. A more appropriate comparison of means would pit equal percentile groupings against each other. One comparison that is more appropriate than the large, established accounts vs. the large, young accounts pits the consumption of the established accounts, small through large size classes (with 89.8th to 99.9th percentiles as boundaries) vs. that of the large, young accounts stratum (with 75.8th and 99.8th percentiles as boundaries). Here, we still find a large difference in average consumption, but not nearly as large as in comparing the large, established accounts vs. the large, young accounts. The mean consumption for the small through large established accounts is 3,127,550 kWh. An even fairer comparison would pit the consumption of the small and medium established accounts (with 89.8th to 99.2nd percentiles as boundaries) vs. the large, young accounts stratum. The mean annualized consumption of the small and medium established accounts strata taken together is 2,009,054 kWh.

4 See the previous endnote for an analogous discussion of comparing means.

5 Additional information concerning hand-out incentives:

A SELF-ASSESSMENT WORKBOOK For Small Manufacturers. Available from Rutgers Office of Industrial Productivity and Energy Assessment, www.oipea.rutgers.edu/documents/doc_f.html

Decision Tools for Industry. CD available from the U.S. DOE OIT Clearinghouse at 800-862-2086 or email Clearinghouse@ee.doe.gov. Individual software "tools" on the CD can be downloaded at www.oit.doe.gov/bestpractices/software_tools.shtml (scroll down towards bottom for reference to the CD).

6 The Code of Federal Regulations mandates the minimum allowable efficiencies of motors sold in the United States. It does not regulate voluntary labeling such as "premium efficiency." NEMA and manufacturers and other private organizations may commit in writing voluntarily to not label a motor "premium" unless it exceeds a certain efficiency threshold, but that is not the same as codification in the CFR. However, the creators of the premium efficiency labeling system for motors chose to follow the size (hp), speed (nominal rpm), and enclosure type classification system as defined in the CFR.

7 Nominal horsepower ratings are not in the middle of the ranges because nominal horsepower ratings came first, not the ranges. When federal policy makers set the standards for efficiency, they followed the lead of the manufacturers and defined efficiency criteria as a function of the nominal horsepower values. The limits to the range then were set at the midpoints between the nominal horsepowers. For example: Consider the nominal hps of 7.5, 10, and 15. The nominal hp of 10 has ranges of 8.75 to 12.5. 8.75 is halfway between 7.5 and 10, and12.49 is halfway between 10 and 15. The nominal hp, 10, is not halfway between 8.75 and 12.49.

8 An example may help explain the ranges chosen in this table: An ideal "4-pole" motor, with no friction, mechanical or electrical losses, a weightless rotor, etc. and no load on the motor would spin at exactly 1800 rpm in any 60-Hz electrical system, which is what we have in North America. This is called the synchronous speed for the motor. Of course no motors are ideal. So most motors are labeled at their actual slowest fully loaded speed (e.g. 1730 rpm). Some motors are labeled with their synchronous speed (1800), but a motor labeled above 1800 rpm is definitely not a 4-pole motor. The synchronous speed is calculated as = (60 cycles/sec * 60 sec/min) / (# of pairs of poles). So any motor above 1800 rpm has to be in the 3600 rpm class.

[9] "General Specification for Consultants, Industrial and Municipal: NEMA Premium(TM) Efficiency Electric Motors (600 Volts or Less)," National Electrical Manufacturers Association, Rosslyn, VA, 2003, p 11-12. Annex A NEMA MG1-1998 Table 12-12.

[10] This section was only asked in Phase 2.

[11] Cutting Energy Waste in Large Refrigeration Systems, Energy Center of Wisconsin, Madison, WI 1999.

[12] Cochran, W., *Sampling Techniques, 3rd Ed,* op cit, pp. 127-131

5. Public Database User Guide

5.1 Introduction

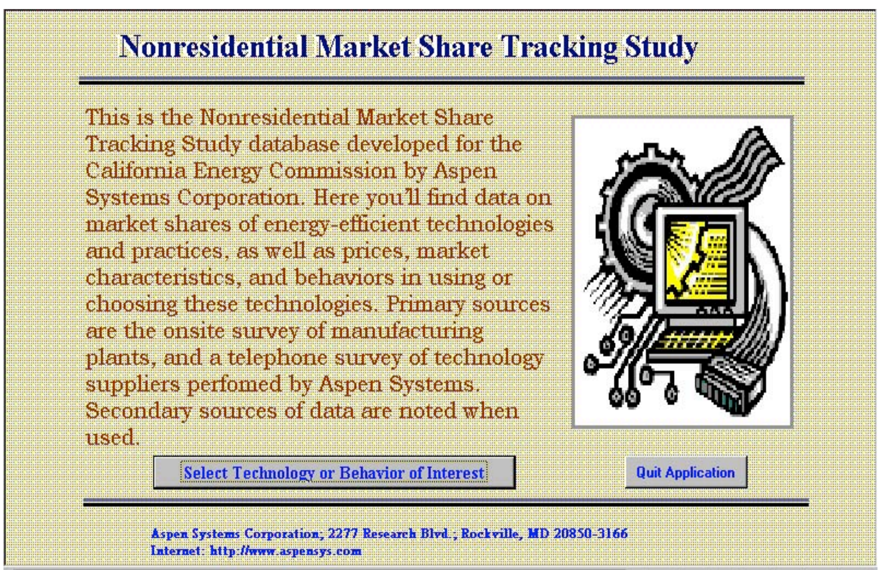
This chapter explains how to display and download summary statistics found in the tracking study. The study collected energy-efficiency market-related data via on-site surveys of manufacturing plants; telephone surveys of windows, lighting, and chiller upstream market actors; and selected data from other related studies. **Please note the selected data cannot replace the full data source from which it is drawn.** For example when you select "DEER" as a data source, you are not accessing the full DEER database, available separately at http://www.energy.ca.gov/deer/.

5.2 Start the Application

5.2.1 Introduction Screen

To open the application, first double-click the **Market Share Tracking Database** icon on your PC desktop or in the directory where the database resides. You will see the screen shown in Exhibit 5-1.

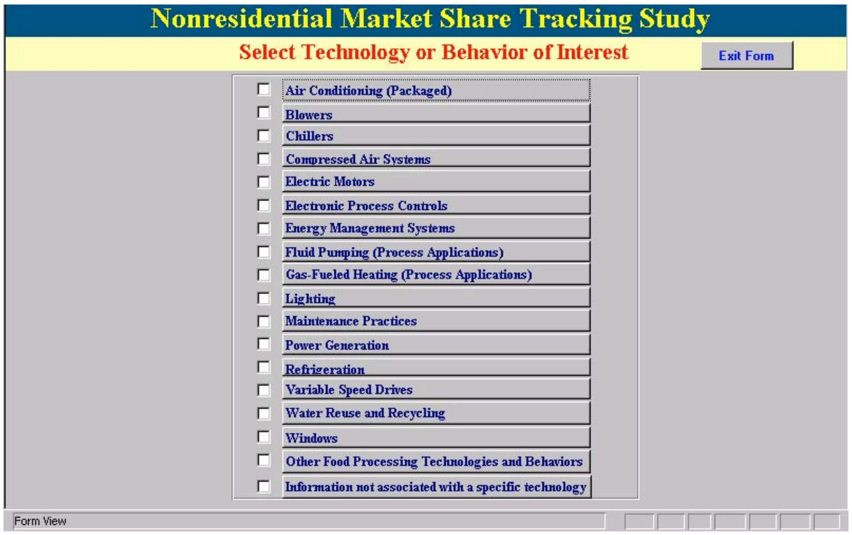
Exhibit 5-1. Introduction Screen



Two buttons are available on this screen:

- **Select Technology or Behavior of Interest** opens a form containing all available technology selections (Exhibit 5-2).
- **Quit Application** brings a "pop-up" prompt that confirms your request to exit the application.

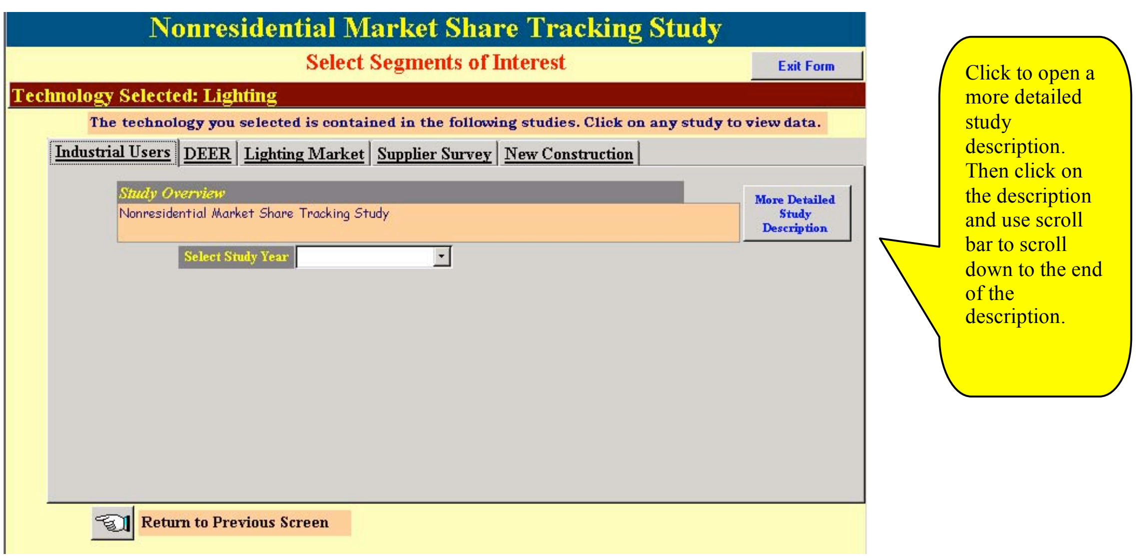
Exhibit 5-2. Select Technology or Behavior of Interest Screen



5.2.2 Select Technology or Behavior of Interest Screen

Click the box next to a technology to select that technology. Only one technology may be selected each time. Clicking a box calls up a **Select Segments of Interest** screen, an example of which is shown in Exhibit 5-3.

Exhibit 5-3. Select Segments of Interest Screen



5.2.3 Select Segment of Interest Screen

This screen has multiple purposes:

a) Select a study that addresses the chosen technology

Seven studies are included in the database: Industrial Users, DEER, Supplier Survey, New Construction, Food Processing, Lighting Market, and Residential Market Share. One or more studies may contain data about the selected technology. If there are multiple studies, a multi-tab form will display with a tab for each study (Exhibit 5-3). Therefore, you need to select a study first by clicking a tab.

However, not all studies contain data for all technologies. Exhibit 5-4 presents the association between the 18 technologies and the seven studies.

Exhibit 5-4. Association Between Technologies and Studies

Technology	No. of Studies	Study Names Displayed in Tabs	Study Title
Air Conditioning (Packaged)	2	DEER Res. Market Share	Database for Energy Efficiency Resources Update Study California Residential Efficiency Market Share
Blowers	1	Industrial Users	Industrial Purchases and Practices Study
Chillers	3	DEER Suppliers Survey New Construction	Database for Energy Efficiency Resources Update Study Nonresidential Market Share Tracking Upstream Market Actor Surveys Non-Residential New Construction Baseline Study
Compressed-Air Systems	1	Industrial Users	Industrial Purchases and Practices Study
Electric Motors	1	Industrial Users	Industrial Purchases and Practices Study
Electronic Process Controls	2	Industrial Users Food Processing	Industrial Purchases and Practices Study California Institute of Food and Agricultural Research Survey on Energy Management in the Food Industry
Energy Management Systems	2	Industrial Users Food Processing	Industrial Purchases and Practices Study California Institute of Food and Agricultural Research Survey on Energy Management in the Food Industry
Fluid Pumping (Process Applications)	1	Industrial Users	Industrial Purchases and Practices Study
Gas-Fueled Heating (Process Applications)	1	Industrial Users	Industrial Purchases and Practices Study

Technology	No. of Studies	Study Names Displayed in Tabs	Study Title
Lighting	5	DEER Lighting Market Industrial Users Suppliers Survey New Construction	Database for Energy Efficiency Resources Update Study C&I New Construction and Retrofit Lighting Design and Practices Industrial Purchases and Practices Study Nonresidential Market Share Tracking Upstream Market Actor Surveys Non-Residential New Construction Baseline Study
Maintenance Practices	2	Industrial Users Food Processing	Industrial Purchases and Practices Study California Institute of Food and Agricultural Research Survey on Energy Management in the Food Industry
Power Generation	1	Industrial Users	Industrial Purchases and Practices Study
Refrigeration	1	Industrial Users	Industrial Purchases and Practices Study
Variable Speed Drives	2	Industrial Users Food Processing	Industrial Purchases and Practices Study California Institute of Food and Agricultural Research Survey on Energy Management in the Food Industry
Water Recovery and Reuse	1	Industrial Users	Industrial Purchases and Practices Study
Windows	3	DEER Suppliers Survey New Construction	Database for Energy Efficiency Resources Update Study Nonresidential Market Share Tracking Upstream Market Actor Surveys Non-Residential New Construction Baseline Study
Other Food Processing Technologies and Behaviors	1	Food Processing	California Institute of Food and Agricultural Research Survey on Energy Management in the Food Industry
Information Not Associated with a Technology	2	Industrial User Food Processing	Industrial Purchases and Practices Study California Institute of Food and Agricultural Research Survey on Energy Management in the Food Industry

b) Select segments on a chosen study tab.

Once a study is selected, it becomes an activated screen. Then you may need to select segments. Different studies have different segments. For example, the Food Processing study has no segments: all results in the Public Database are for the entire state, one industry, and one point in time. By contrast, the Industrial User study has data for hundreds of segments, chosen on the basis of year, region of the state, and industry of interest to the user. Section 5.3 outlines the segments available for each study contributing data to the Public Database. Exhibit 5-5 shows the selection of segments for the Industrial Users Study.

c) Select Interest Button.

After segments are chosen from the study of interest, click the **Select Interests on Next Screen** button (Exhibit 5-5, lower right corner). Once this is activated, the **Select Segment Screen** is replaced with the **Select Description of Interest** screen (Exhibit 5-6). Note: Only those descriptions will appear where data exists for criteria specified.

Exhibit 5-5. Select Segments of Interest for Industrial Users Study

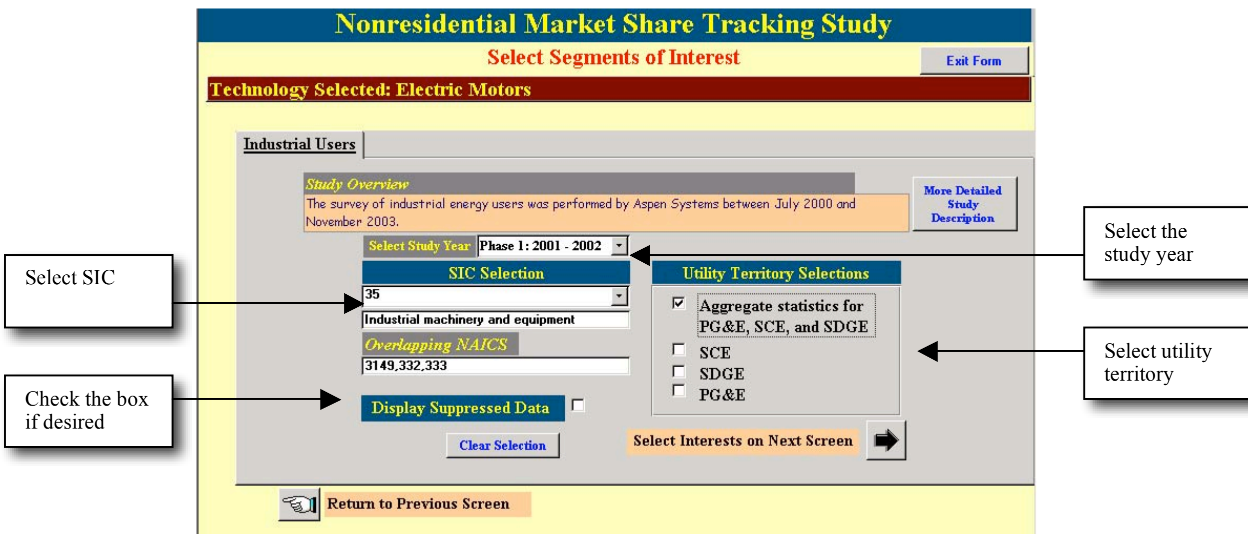
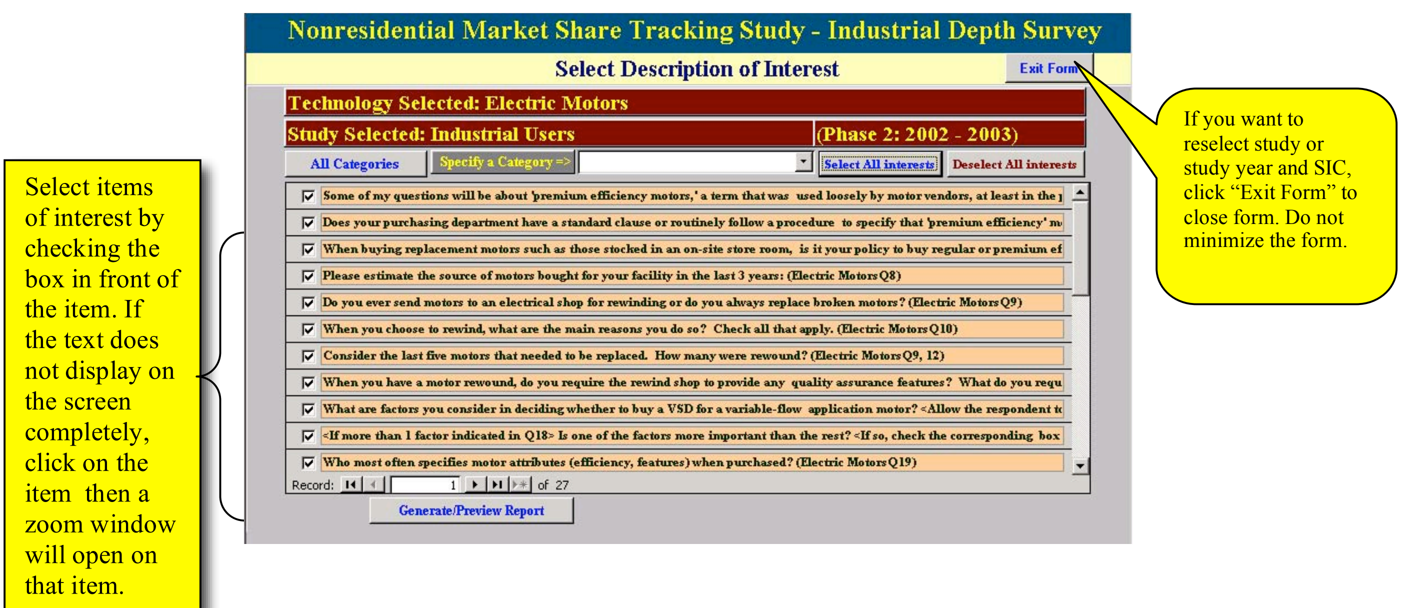


Exhibit 5-6. Select Description(s) of Interest



5.2.4 Select Description of Interest

This screen reveals all the concepts or variables that are available for tabulation in the selected segments of the selected study for the selected technology and criteria specified on the previous screen. Exhibit 5-6 illustrates the concepts available for electric motors from the Industrial Users' Study, in Phase II (2002-2003), for the selected locations and industries.

5.3 Choose and Display Estimates of Interest

5.3.1 Introduction

One or more studies may contain data about the selected technology. If there are multiple studies, a multi-tab form will display with a tab for each study (Exhibit 5-3). Click **More Detailed Study Description** for more details on each study.

5.3.2 Industrial Purchases and Practices Study

View summary data from the Industrial Purchases and Practices Study via the **Industrial Users** tab. The first four steps apply to Exhibit 5-5; the rest apply to Exhibit 5-6.

a) Select the study year from the drop-down list by clicking the down arrow next to the blank field.

b) In the **SIC Selection** pull-down menu, select a particular industry grouping or aggregate statistics for all the industries surveyed.

c) If you selected **Phase 1: 2001-2002** or **Phase 2: 2002-2003** AND you selected the aggregate statistics choice in Step b, choose a utility service territory or aggregate statistics applying to PG&E, SCE, and SDG&E.

d) Click on the **Select Interests on Next Screen** button to display the next screen (Exhibit 5-6). Note: Only those descriptions will appear where data exists for criteria specified.

e) Depending on the selected technology, you may be able to restrict the estimates displayed to those within your choice of the following categories:
    - Technology Shares, Costs, and Quantities
    - Indicators of Practices Relating to Energy Efficiency
    - Decision Factors
    - Market Pathways
    - Other Market Characterization Attributes

   Select the category of interest (Exhibit 5-6) using the drop-down box next to the **Specify a Category** label. Alternatively, clicking on the **All Categories** button near the top left of the form will select all available categories.

f) Descriptions of estimates fitting the criteria selected will display with a label indicating the questionnaire section and question numbers on which the estimates are based. **NOTE: If a description is too long to fit completely on the screen, click on the description to view the entire description in a separate window**.

g) Click each item of interest for which you wish to view more data. Multiple selections are allowed. Clicking **Select All** will select all available items; clicking **Deselect All** will clear all selections.

h) Click the **Generate/Preview Report** button (bottom of Exhibit 5-5) to see the summary statistics corresponding to your selections.

i) Click **Exit Form** to return to the previous screen. **CAUTION: You MUST use this button to close the form.**

5.3.3 Database for Energy Efficiency Resources (DEER) Update Survey

View selected data from DEER via the **DEER** tab (Exhibit 5-7):

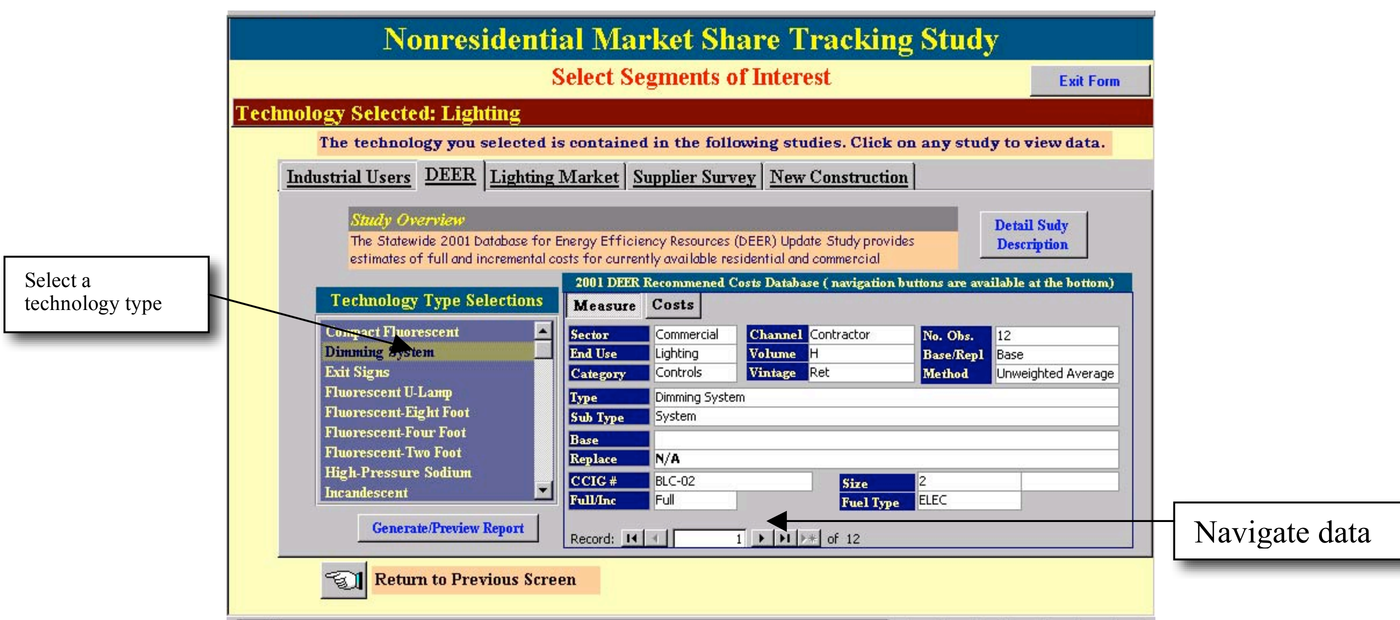
a) Select a technology type in the list box on the left, scrolling as needed.

b) View data displayed in the sub-form on the right of the screen. Pressing the **Cost** button displays the cost data associated with the measure shown on the screen. Pressing the **Measure** button moves back to the description of the technology and cost estimation method. Use the buttons at the bottom to move to different records.

c) Click the **Generate/Preview Report** button near the bottom to see available cost estimates for each member of the category in the box on the left.

d) Click **Exit Form** to return to the previous screen.

Exhibit 5-7. DEER Tab



5.3.4 C&I New Construction and Retrofit Lighting Design and Practices Study

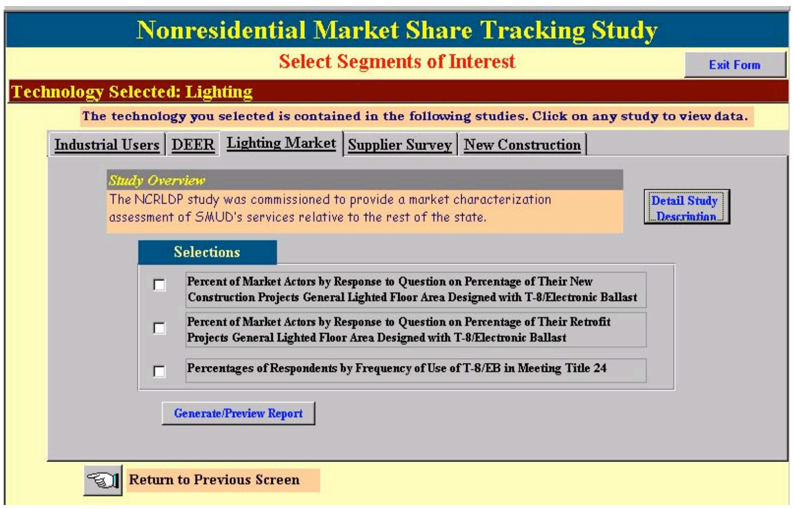
View selected data from the 2000 New Construction and Retrofit Lighting Design and Practices Study via the **Lighting Market** tab (Exhibit 5-8):

a) Click the check box in front of any topic to view applicable data. Only one topic can be selected at a time.

b) Click the **Generate/Preview Report** button near the bottom to see the results of your selections.

c) Click **Exit Form** to return to the previous screen. **CAUTION: You MUST use this button or the button Return to Previous Screen to close the form.**

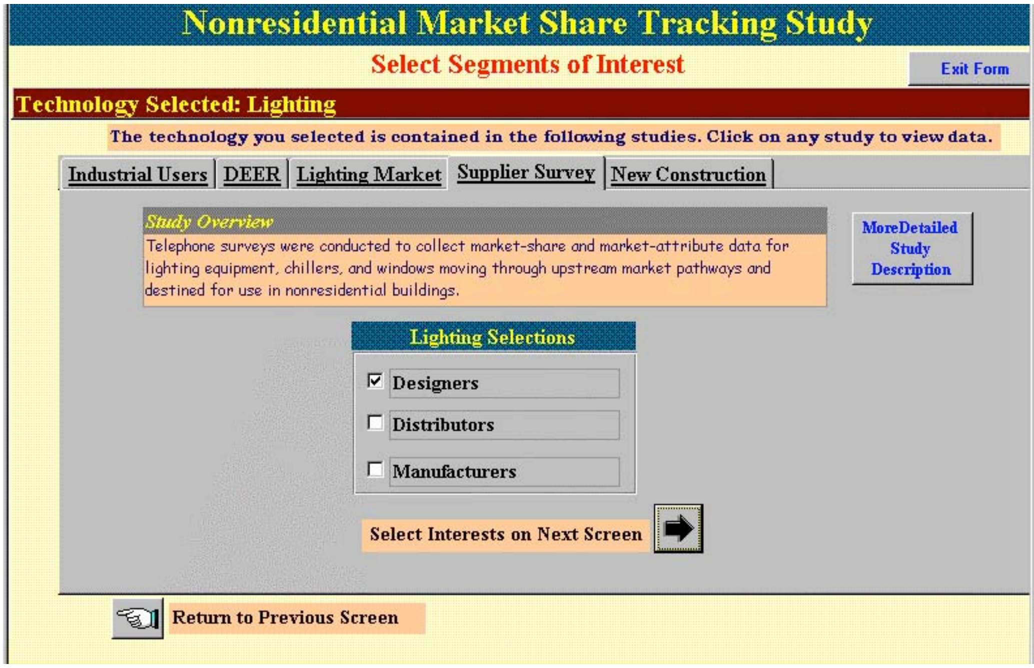
Exhibit 5-8. Lighting Market Tab



5.3.5 Nonresidential Market Share Tracking Study Upstream Market Actors Survey

View summary data from Nonresidential Market Share Tracking Study Upstream Market Actors Surveys via the **Supplier Survey** tab (Exhibit 5-9).

Exhibit 5-9. Supplier Survey Tab



a) Different market actor groups will display depending on the technology selected on the previous screen. Click the check box in front of the group whose answers you would like to see summarized. Only one group can be selected at a time. Note, there was only one market actor group for Windows, so no market actor group choices will display.

b) Click the **Select Interests on Next Screen** button. Exhibit 5-10 provides an example screen that appears.

Exhibit 5-10. Select Description(s) of Interest

c) Depending on the technology selected, you may be able to restrict the estimates displayed to those within your choice of the following categories:
- Technology Shares, Costs, and Quantities
- Indicators of Practices Relating to Energy Efficiency
- Decision Factors
- Market Pathways
- Other Market Characterization Attributes

Select the category of interest by using the dropdown box next to the **Specify a Category** label. Alternatively, clicking on the **All Categories** button near the top left of the form will select all available categories.

d) Descriptions of estimates fitting the criteria you selected will display with a label indicating the survey question numbers on which the estimates are based. If a description is too long to fit completely on the screen, click on the description to call up the entire description in a separate window.

e) Click each item of interest for which you wish to view more data. Multiple selections are allowed. Clicking **Select All** will select all available items; clicking **Deselect All** will clear all selections.

f) Click the **Generate/Preview Report** button (bottom of Exhibit 5-10) to see the summary statistics corresponding to your selections.

g) Click **Exit Form** to return to the previous screen. **CAUTION: You MUST use this button or the button Return to Previous Screen to close the form.**

5.3.6 Non-Residential New Construction Baseline Study

View selected summarized data from the 1999 Non-Residential New Construction Baseline Study via the **New Construction** tab (Exhibit 5-11).

a) Select a utility service territory from **Territory Selections** from the list. Only one selection is allowed.

b) Select a building type from the **Building Type Selections** list. Multiple selections are allowed. Note, you can select either **All Buildings** or multiple other types, but NOT both.

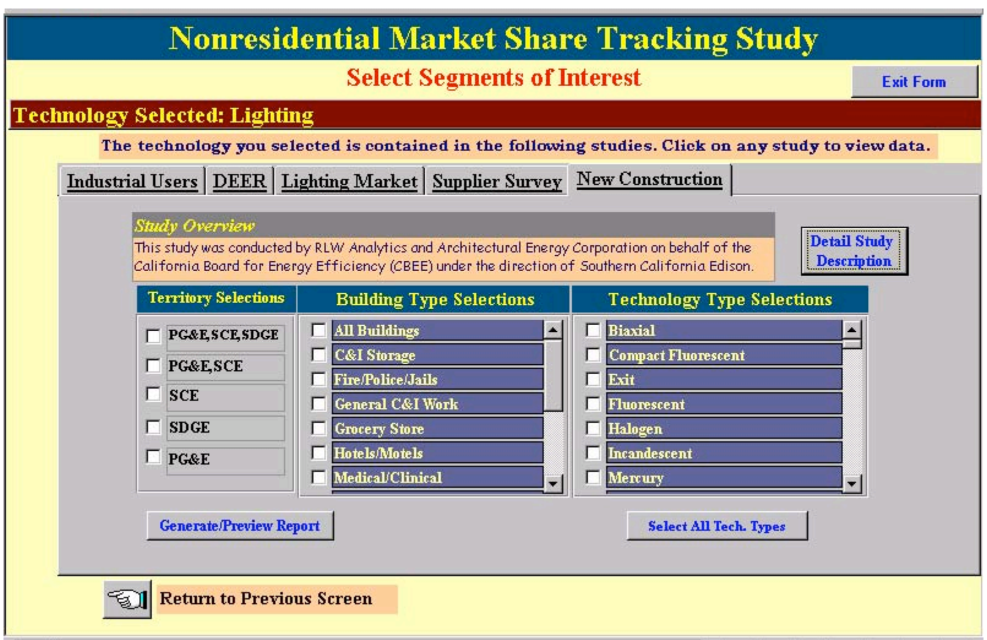
c) Select technology types from the list. Multiple selections are allowed.

d) You may use the **Select All Tech. Types** button beneath this list to select or deselect all technology types.

e) Click the **Generate/Preview Report** button at the bottom of the page to see the summary statistics corresponding to your criteria.

f) Click **Exit Form** to return to the previous screen. **CAUTION: You MUST use this button or the button Return to Previous Screen to close the form.**

Exhibit 5-11. New Construction Tab



5.3.7 California Institute of Food and Agricultural Research Survey on Energy Management in the Food Industry

View selected data from the California Institute of Food and Agricultural Research Survey on Energy Management in the Food Industry via the **Food Processing** tab (Exhibit 5-12).

a) Click the check box in front of a topic on which you wish to view applicable data. Only one topic can be selected each time.

b) Click the **Generate/Preview Report** button at the bottom of the page to see the results of your selections.

c) Click **Exit Form** to return to the previous screen. **CAUTION: You MUST use this button or the button Return to Previous Screen to close the form.**

Exhibit 5-12. Food Processing Tab

5.3.8 California Residential Efficiency Market Share Tracking Study

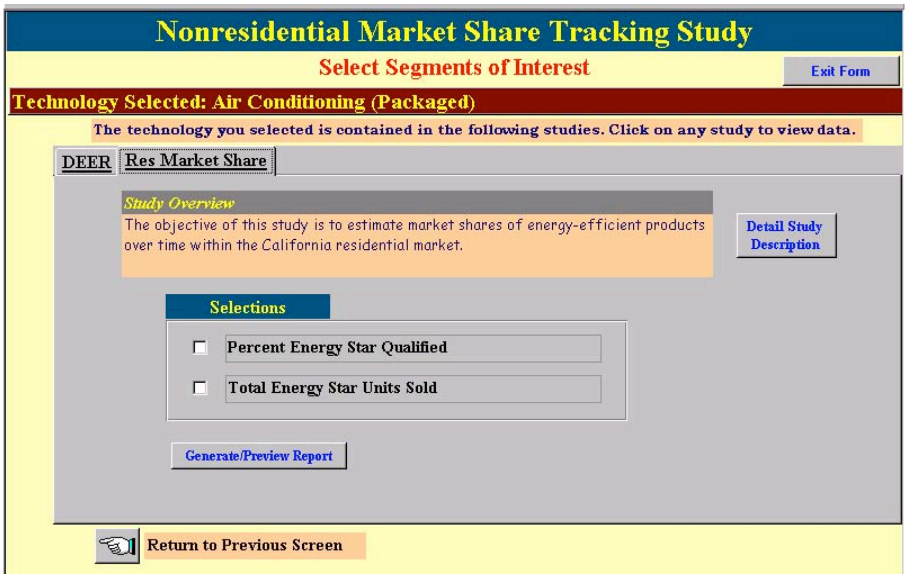
View selected data from the 2000 California Residential Efficiency Market Share Tracking Study via the **Res. Market Share** tab (Exhibit 5-13).

a) Click the check box in front of any topic to view applicable data. Only one topic can be selected each time.

b) Click the **Generate/Preview Report** button at the bottom of the page to see the results of your selections.

c) Click **Exit Form** to return to the previous screen. **CAUTION: You MUST use this button or the button Return to Previous Screen to close the form.**

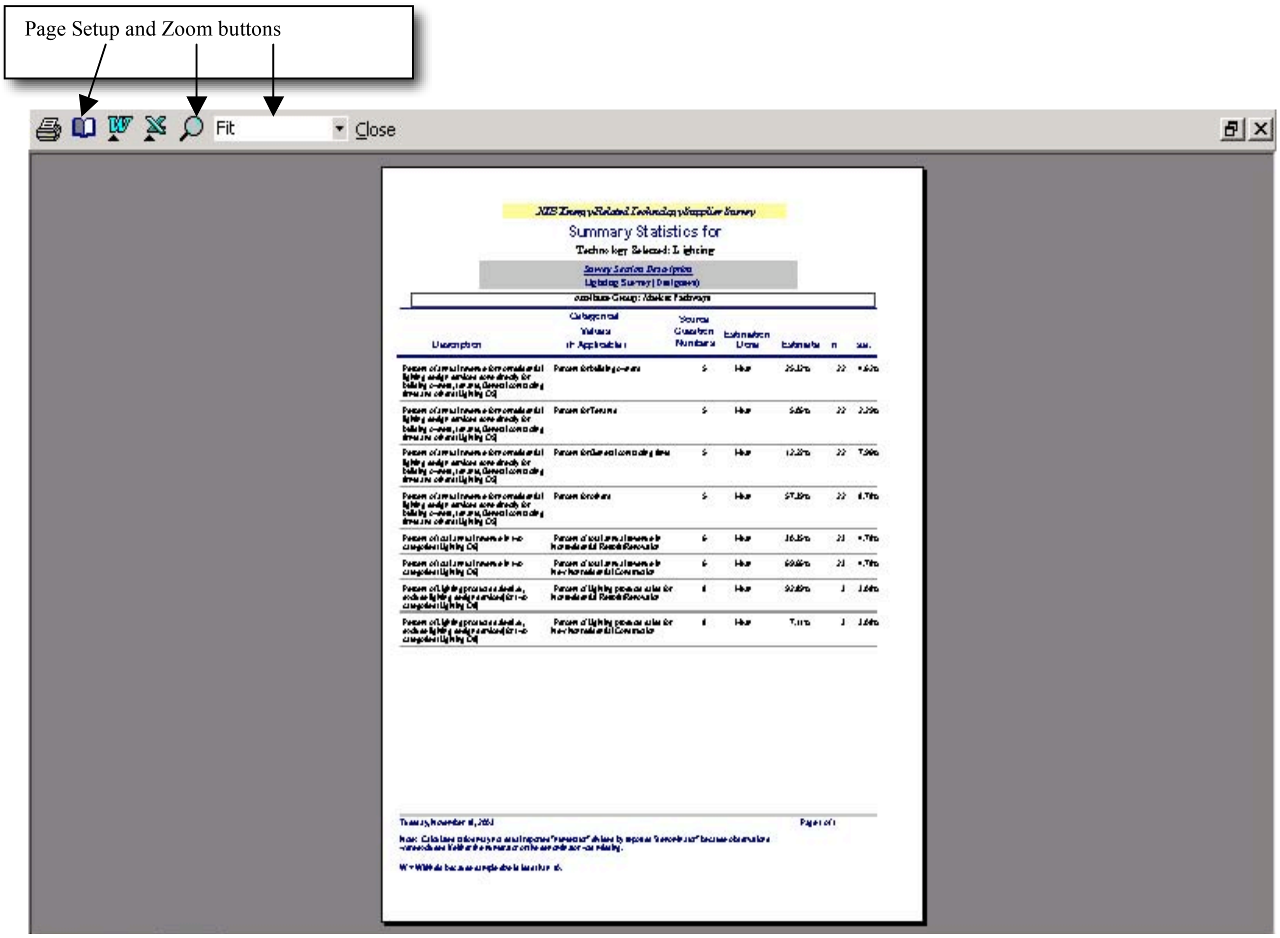
Exhibit 5-13. Res. (Residential) Market Share Tab



5.4 Output Data

You may adjust output format via the **Page Setup** and **Zoom** icons on the menu bar at the top of reports you produce. Pop-up screens allow you to change factors such as paper size, orientation, margins, and display size on the screen (Exhibit 5-14).

Exhibit 5-14. Print/Output Report



5.4.1 Print Report

To print a report, click the printer icon on the menu bar. Click **Close** on the menu bar to return to the previous screen.

5.4.2 Output Data to a File

You can output reports you create to Excel or Word (rtf). To do this, click on an **OfficeLink** icon (***[W]*** for Word; ***[X]*** for Excel) on the menu bar at the top of the screen.

6. Database Development and Structure

6.1 Introduction

As specified in the Research Plan, Aspen optimized the data integrity of the Nonresidential Market Share database by developing a master database in Microsoft ACCESS 97. This master database is a composite of two separate databases: the Confidential Database and the Public Database. The Public Database contains summary and non-confidential data derived from the Confidential Database using systematic data extraction routines.

This chapter describes each of these databases, including a database outline that lists the tables in the database, a database relationship diagram with description, and a discussion of programming related to queries, reports, and quality control.

The Confidential Database contains all of the confidential data collected under the secondary data collection efforts, the primary on-site survey effort, and the primary telephone survey effort. The Public Database contains summary and non-confidential data derived under the effort to estimate summary statistics of the industrial populations. Appendices D and K list and describe all of the data elements contained in each of the tables of these databases.

6.2 Confidential Database

This section describes the contents of the Confidential Database, which includes data collected from various sources described below.

Confidential Industrial Survey Data

The tables listed here contain all individual survey data collected during the industrial on-site surveys in 2001–2002 and 2002–2003. The survey contains the following sections and components:

- General
- Motors
- Motor Sample
- Fluid Pumping Process Systems (Phase 2 only)
- Compressed Air
- Maintenance Practices
- Electronic Control of Process Equipment
- Gas Process Heating (Phase 2 only)
- Water Reuse
- Power Generation
- Refrigeration
- Closing

- Telephone Survey

Each item represents two separate tables in the database: one for the 2001–2002 data collection and the second from the 2002–2003 surveys. Exhibits 6-1 and 6-2 depict the relationships between these tables for each phase.

Exhibit 6-1. Confidential Database Diagram—Phase 1

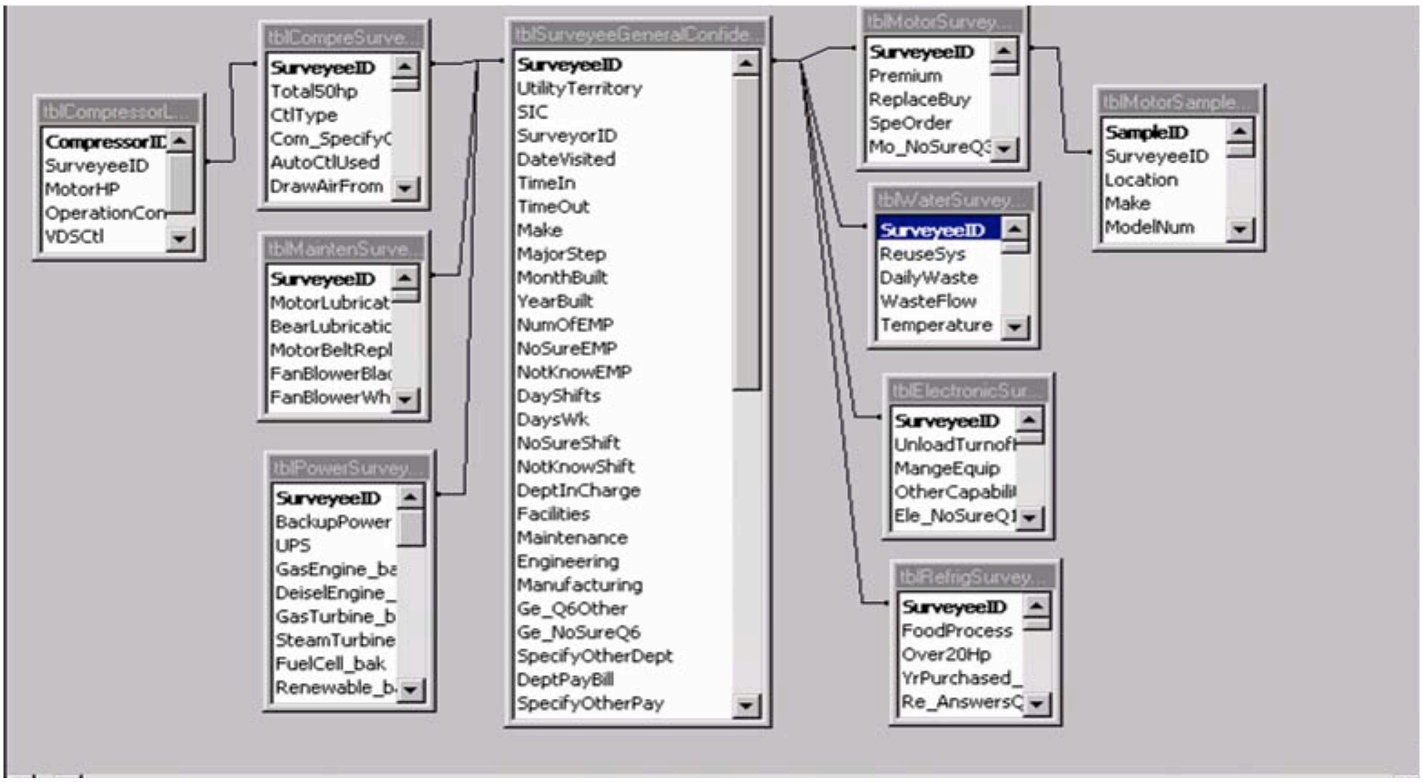
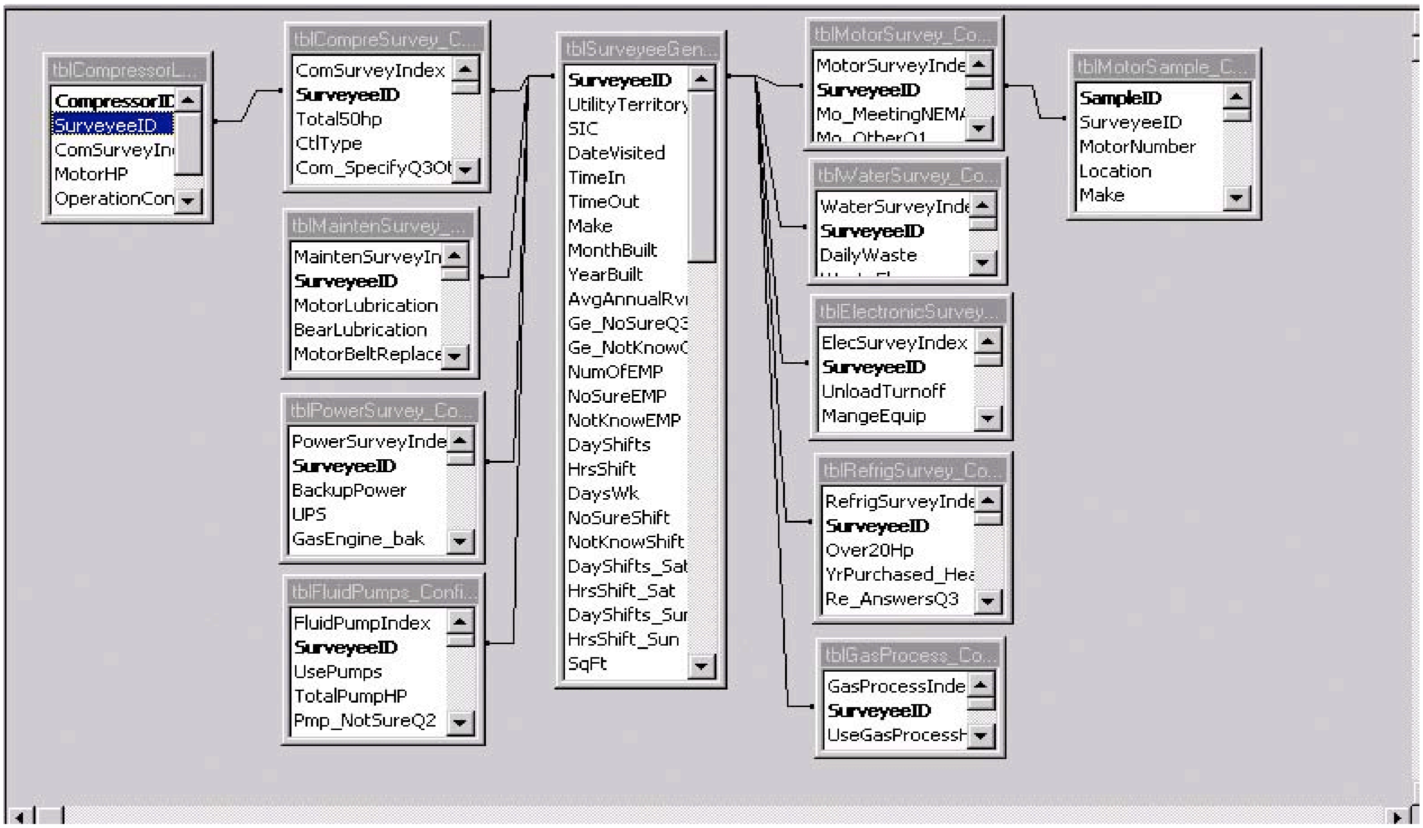


Exhibit 6-2. Confidential Database Diagram—Phase 2



Confidential Upstream Market Actor Survey Data

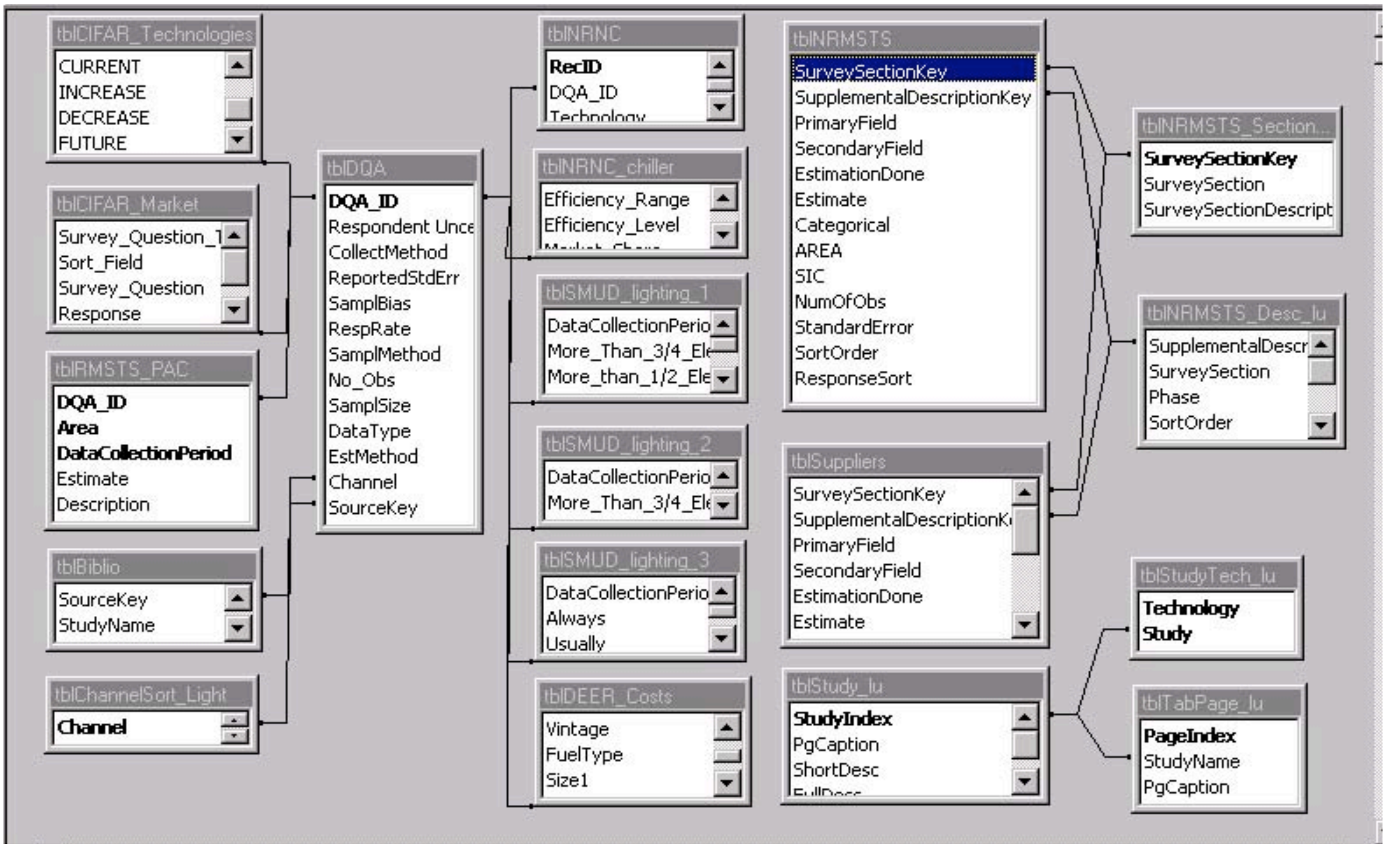
Data collected during the market actor telephone survey interviews have been tabulated for the following market segments:

- Lighting wholesalers and distributors
- Lighting designers
- Lamp and ballast manufacturers
- Chiller manufacturers
- Chiller installers and designers
- Windows vendors and installers

6.3 Public Database

This section describes the non-confidential data derived from the Confidential Database described in Section 6.2. Exhibit 6-3 shows the relationships between the tables in the database.

Exhibit 6-3. Public Database Diagram



Public Industrial Survey Data

The data collected in the on-site industrial survey have been analyzed and summarized into non-confidential data tables. Summary data are presented for each of the following sections of the industrial survey:

- General
- Motors
- Compressed Air
- Fluid Pumping Process Systems
- Maintenance Practices
- Electronic Control of Process Equipment
- Gas Process Heating
- Water Reuse
- Power Generation
- Refrigeration
- Closing

Public Secondary Source Data

During the secondary data search effort, data were collected from other studies that relate to the subject of this contract. Summary data have been added to this database from the following sources:

- California Institute of Food and Agricultural Research Survey on Energy Management in the Food Industry
- Database for Energy Efficiency Resources (DEER) Update Study
- C&I New Construction and Retrofit Lighting Design and Practices, commissioned by SMUD
- Non-Residential New Construction Baseline Study commissioned by the California Board for Energy Efficiency (CBEE)
- California Residential Efficiency Market Share Tracking Study

Public Upstream Market Actor Survey Data

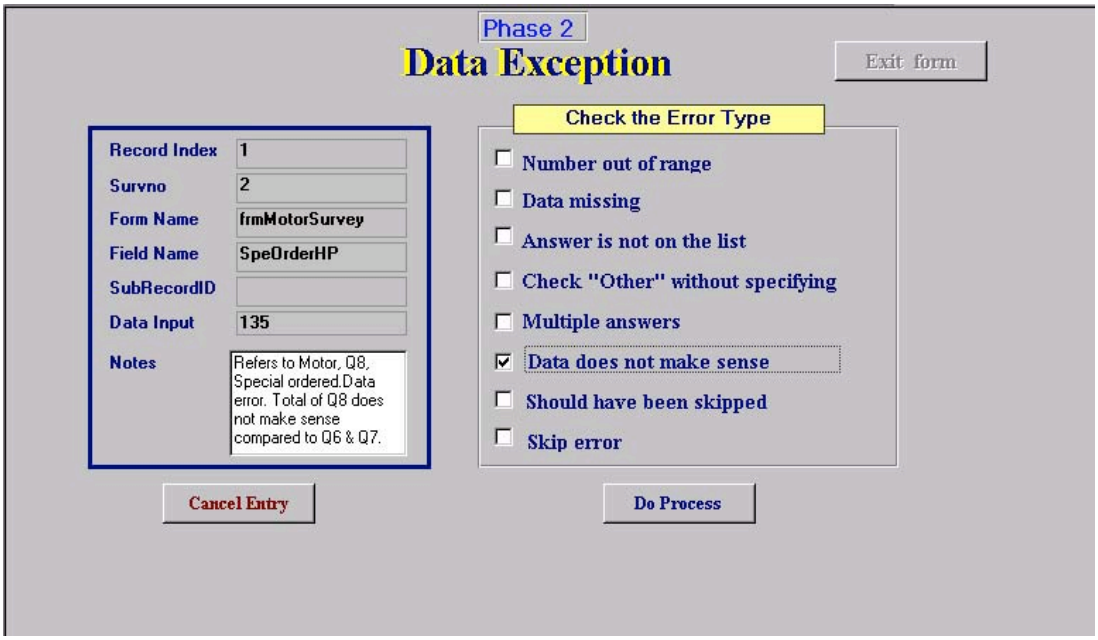
Data for the following three technologies collected during Task 5 have been analyzed and stored as non-confidential data:

- Lighting
- Chillers
- Windows

6.4 Programming and Design for Data Quality

Aspen has programmed all data entry screens to facilitate the speed and the quality of the data entry. Quality control specifications were programmed into on-site survey data entry screens as appropriate. The programming provides pop-up windows to alert data entry personnel when invalid or suspicious data are entered. The program includes range checks, data validity checks, and rules to enforce data integrity. If data entry personnel continue with entry of that data, an "exception" message is inserted to a table and later printed to a report (Exhibit 6-4). A supervisor, who determines if the data anomaly should be referred back to the surveyor for correction or clarification, reviews the report. After the review is complete, the correct values are entered and the exception record updated at the same time. The report of exceptions is run again to ensure that all exceptions have been properly handled. Appendices I and J contain lists of quality control checks for Phases 1 and 2. These appendices include data quality checks performed during Phases 1 and 2 data entry.

Exhibit 6-4. Sample Data Entry Screen with Exception Record



Future data entry and updating can utilize the same or similar data integrity rules that will help to ensure the quality and comparability of future data entry and updating.

6.5 Programming and Design to Display Non-Confidential Data

Aspen has structured linkages in the Public Database so that desired queries specified by the user are possible. Aspen developed this application in MS ACCESS 2002. A run-time version of this database and application has been developed for distribution to PCs that do not have ACCESS installed. The application provides easy-to-use screens that allow the user to select the desired data for viewing from the vast amount of summary data available. As an example, after the user selects a technology, such as “Compressed-Air System”, Exhibit 6-5 is displayed, allowing the user to make selections unique to each study. In this example, the user selects the study year, SIC, and utility territory. Following this selection, Exhibit 6-6 is displayed for the user to select a category of interest and specific analysis details. When these selections are complete, a report is displayed for the selections made. Exhibit 6-7 is the report generated when the Study **Industrial Users,** the Study Year **Phase 2: 2002 - 2003**, the **All Phase 2** SICs, **Aggregate Statistics for PG&E, SCE, and SDG&E** utility territories, and **All** categories of interest are selected. This application is described in detail in Chapter 5.

Exhibit 6-5. Select Segments of Interest for Industrial Users

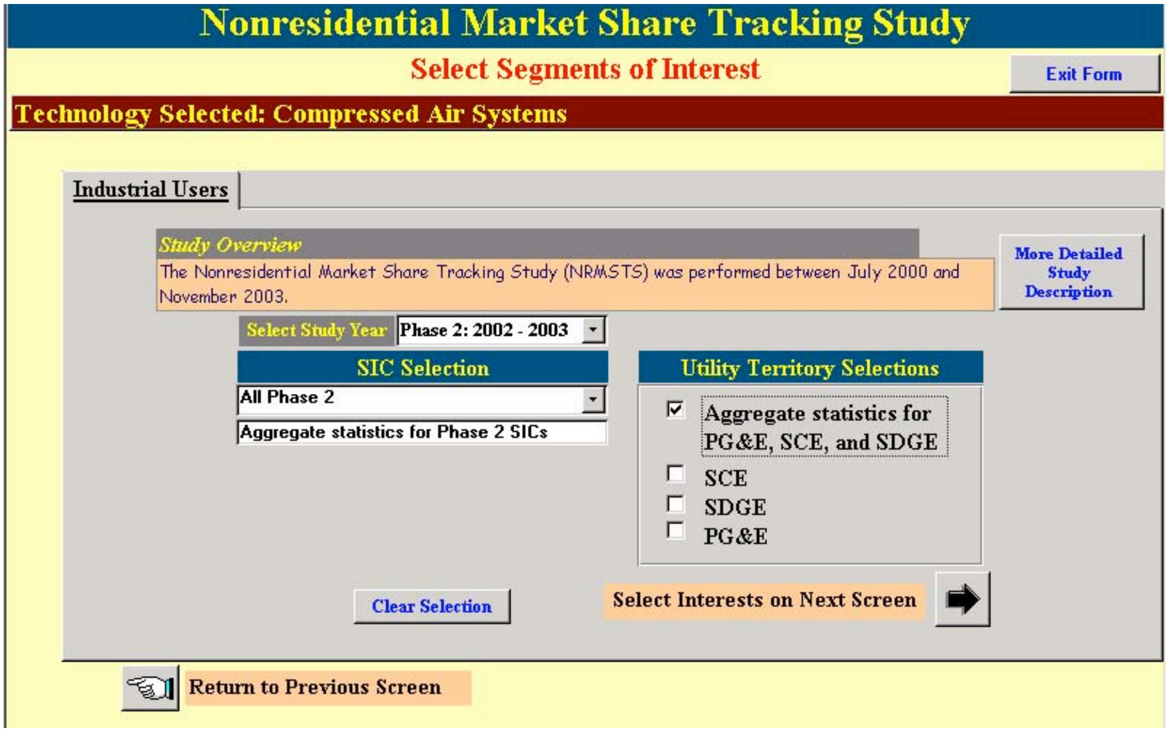


Exhibit 6-6. Select Descriptions of Interest

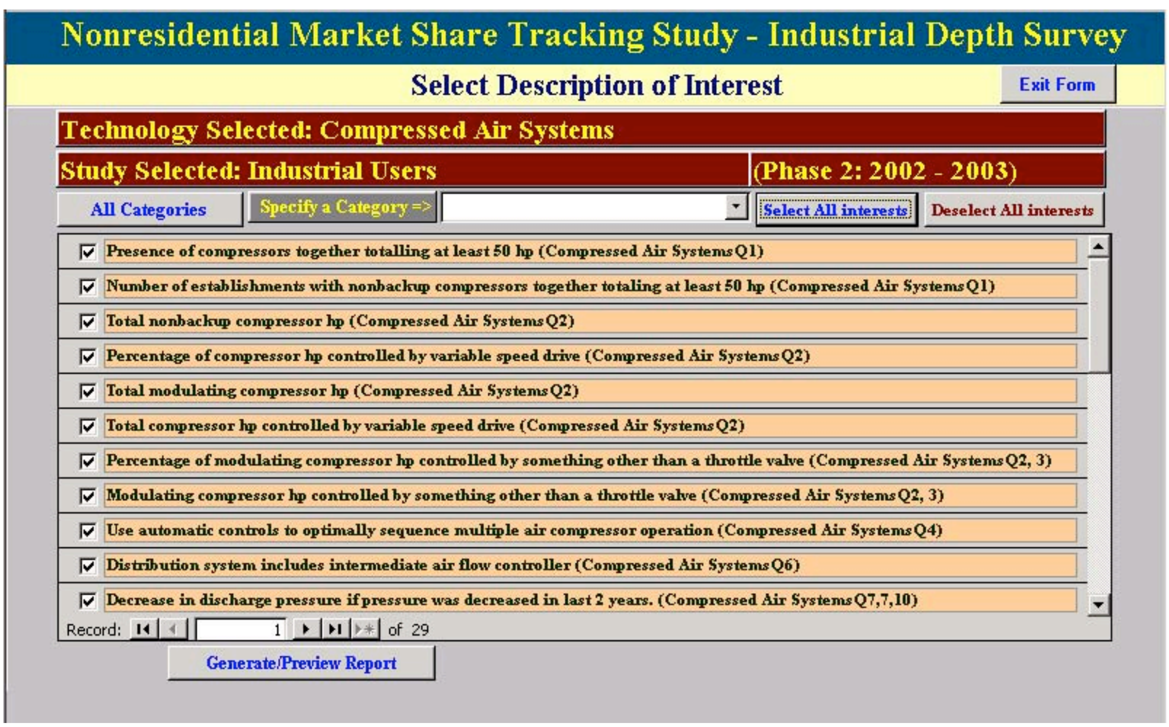


Exhibit 6-7. Sample Query Output Report

Industrial Purchases and Practices Survey

Summary Statistics for

Technology Selected: Compressed Air Systems

Area Selected: **PGE, SCE, SDGE**

SIC Selected: **21-34, 37-39**

Phase Selected: **Phase 2: 2002 - 2003**

Survey Section Description

Compressed Air (Applies to establishments with nonbackup compressor together totaling at least 50 hp)

Note: Calculations, e.g. denominators, exclude respondents who were supposed to skip relevant question.

Description	Categorical Values (If Applicable)	Estimation Done	Estimate	n	s.e.
Presence of compressors together totaling at least 50 hp (Compressed Air Systems Q1)	Yes	Percentage of Sites	35.3%	324	5.7%
Presence of compressors together totaling at least 50 hp (Compressed Air Systems Q1)	No	Percentage of Sites	64.7%	324	5.7%
Presence of compressors together totaling at least 50 hp (Compressed Air Systems Q1)	Missing	Percentage of Sites	0.0%	324	0.0%
Number of establishments with nonbackup compressors together totaling at least 50 hp (Compressed Air Systems Q1)	NA	Sum	8,244	174	NA
Percentage of compressor hp controlled by variable speed drive (Compressed Air Systems Q2)	NA	Ratio	5.7%	192	1.8%
Total nonbackup compressor hp (Compressed Air Systems Q2)	NA	Sum	940,613	192	88,736
Total modulating compressor hp (Compressed Air Systems Q2)	NA	Sum	598,506	183	79,141
Total compressor hp controlled by variable speed drive (Compressed Air Systems Q2)	NA	Sum	53,620	192	16,259
Percentage of modulating compressor hp controlled by something other than a throttle valve (Compressed Air Systems Q2, 3)	NA	Ratio	33.4%	183	12.0%